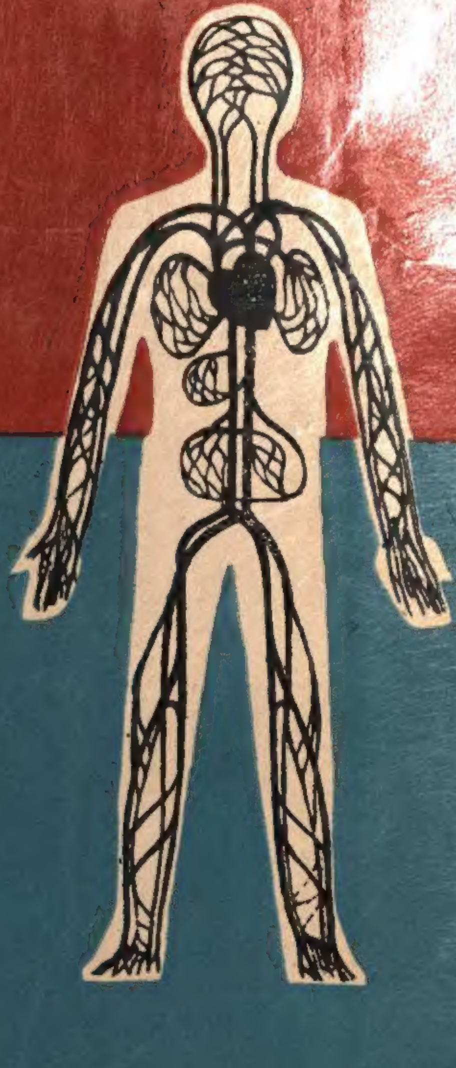
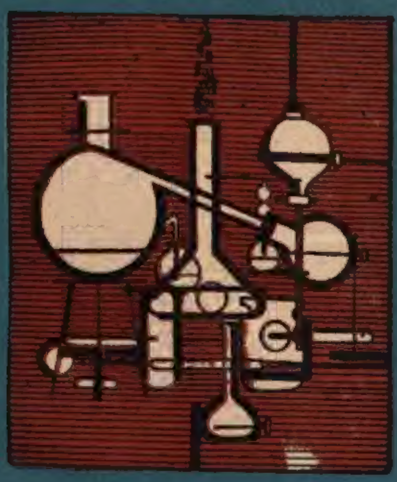
Ambar

LEARNING SCIENCE

II





AMBAR PARKASHAN

Based in accordance with the latest syllabus prescribed by N.C.E.R.T., New Delhi for Class VII in Integrated Science.

AMBAR LEARNING SCIENCE

(Physics, Chemistry, Life Sciences, etc.)

BOOK II

(For Class VII)

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PREFACE TO THE FIRST EDITION

It is considered necessary to initiate a new approach to the study of Integrated Science at the school level. At present the emphasis in Science-teaching is on the pupil making discoveries by investigation and on the understanding rather than on the memorization of facts.

The new approach to the study of Integrated Science demands the active participation of students in the learning process through experimentation. This approach leads to a proper understanding by the students of the basic concepts of Science and enables them to discover new ideas.

The efforts of the authors have been to relate, as far as possible, the teaching of Integrated Science to what a student see and does in everyday life. The thrill and excitements of doing experiments help the students to understand the subject and find something new for himself. Students are curious ; they search to understand the unknown and so an interest in learning develops. Efforts have been made here to involve the pupil, physically and emotionally, to make the learning of science a personal experience.

This series has been designed to meet these needs. The language used is simple and concise. The text has been attractively illustrated with many clearly labelled diagrams. Carfully planned out questions are given in the text to teach the pupils to reason and to arrive at logical conclusions. The experiments and activities have been carefully designed to fit naturally into their inquiry and are such that every teacher and student can perform without difficulty.

The authors would feel happy if this book could satisfy the needs of the students of the middle school classes and help them to understand and appreciate the applications of the fundamentals of Intergrated Science in everyday life. Suggestions for improvement of this book would be gratefully accepted from fellow science teachers, students and parents.

—***Authors***

PREFACE TO THE REVISED EDITION

The present edition has been thoroughly revised. At many places, new explanation has been added to make the book more comprehensive. A large number of *Objective type* and *Short answer questions* have been included to help the students in self testing. A number of new diagrams have been added to make the matter self explanatory.

Suggestions for further improvement are welcome.

—***Authors***

CONTENTS

1

MOTION, MASS, FORCE (FRICTION), PRESSURE AND BUOYANCY

1.1. Motion

In our everyday life, we see many objects moving, such as a person walking on the road, a boy running on the playground, the vehicles and cattle moving on the road, a bird flying, etc. They continually change their positions, some moving slowly and some moving fast. When we consider whether a body is moving or not, we usually take the stationary objects such as trees, houses, lamp posts, etc., on the surface of the earth as reference.

You are travelling in a moving train. There are many other passengers in your compartment. Is there any change in your position with respect to the other passengers eventhough you are moving with the train ? Look at nearby trees or telegraph posts outside. What do you observe ?

The continuous change of position of a body with respect to another is called mechanical motion. There are different types of mechanical motion such as translatory, rotatory and oscillatory.

Translatory Motion

In this motion, a body is moving such that each of its particles has exactly the same displacement along with the body. For example, the motion of a drawer of a table, drawing

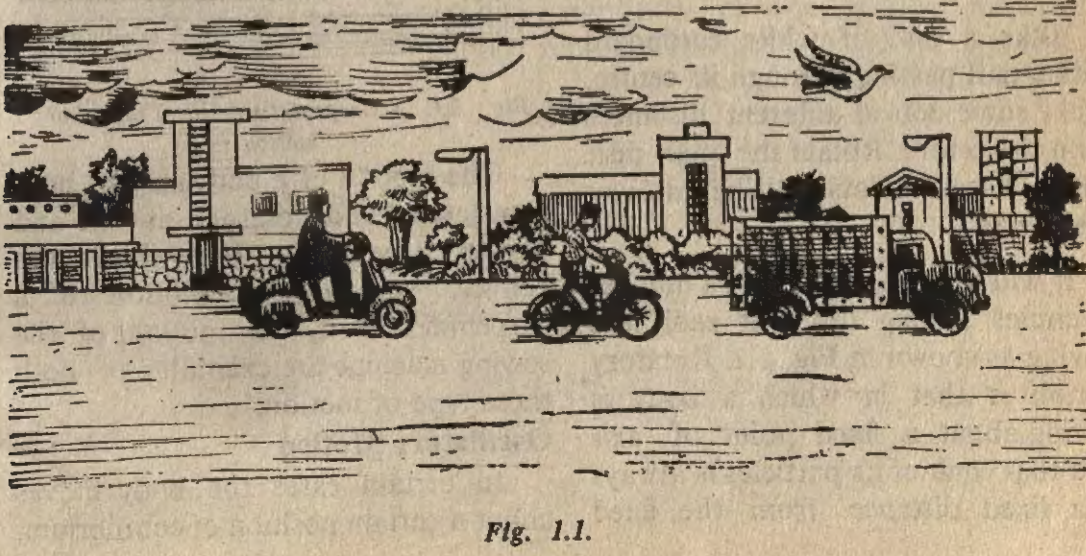


Fig. 1.1.

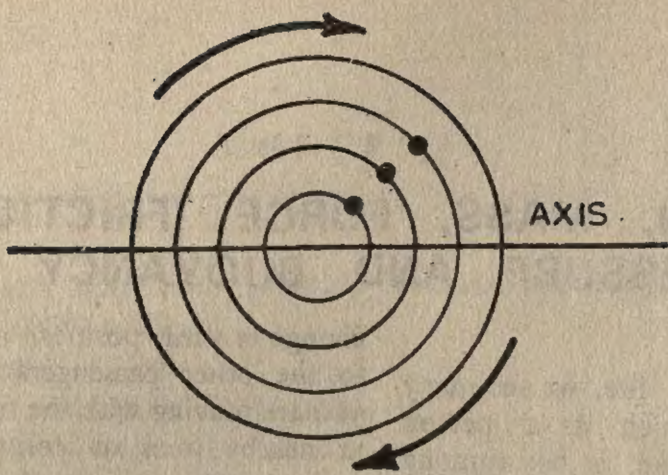


Fig. 1.2.

a line on a blackboard, etc. In each of these cases, each part of the body follows a similar and equal path. It is not necessary that the path in translatory motion should always be straight. If the path followed by a moving body is straight, the motion is said to be *rectilinear* and if it is curved, the motion is *curvilinear*.

Rotatory Motion

Activity 1.1 :

Take a disc of white cardboard with a nail passing through its centre. Make some dots at different distances from the centre. Rotate the disc fast. Can you see the dots ? What do you observe ?

It will appear to you that a number of circles having different radii are moving as shown in Fig. 1.2. Rotatory motion is that in which a body is moving about a fixed point of axis such that each of its particles is always at a fixed distance from the fixed point or axis. The motion of a pulley, wheel, gramophone disc are examples of rotatory motion.

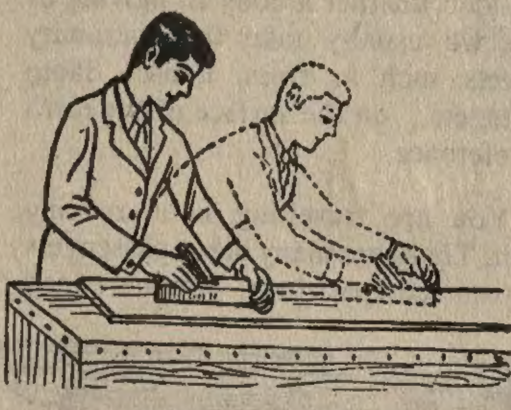


Fig. 1.3. A Carpenter's drill—Translatory motion

The motion of a body may be both translatory and rotatory at one end at the same time. The wheels of a railway wagon, the motion of a carpenter's drill, the motion of the sewing machine are examples of both these type of motion.

Oscillatory Motion

In certain cases the body moves about a certain position of equilibrium.

Fig. 1.4. A Swing in Oscillatory motion

First it moves a certain distance away from it, then returns to the position of equilibrium, passes it and goes to the other side and again comes back. Such a type of motion is called oscillatory motion.

The swing and the pendulum are examples of oscillatory motion (Fig. 1.4.)

1.2. Displacement

Distance in a particular direction between two successive positions of a moving body is known as its *displacement.*

A cricketer runs 20 metres from A to B as shown in Fig. 1.5 and then 18 metres on his return run before being run out. What was his displacement from A when the bails were knocked off ? If the displacement has to describe the length AC as shown in Fig. 1.5 we will need to know not only that it is 2 metres (magnitude) but also that it is measured along the line AB from A (direction). It is convenient to represent displacement by a line and arrow-head. The magnitude of the displacement is represented by the length of the line

Fig. 1.5.

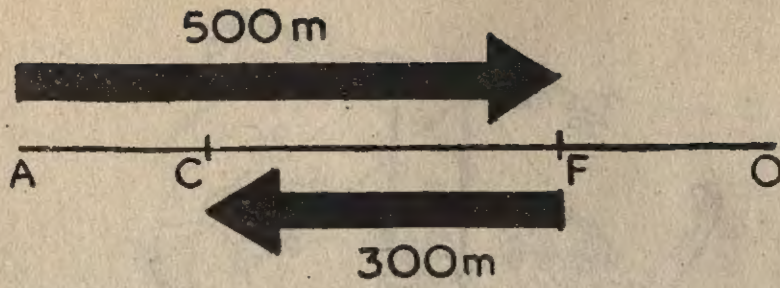


Fig. 1.6.

and the direction of the displacement is shown by the arrow-head. Lines of this kind are called *vectors.*

Displacement is a *vector quantity*, that is, it is fully described only when both its magnitude and direction are given. When a quantity can be described fully by a number (magnitude) it is called a *scalar quantity.* Distance is a scalar quantity.

Suppose a boy goes a distance of 500 metres along a particular direction AO which is represented in Fig. 1.6.

Let us call this trip AF. He then returns along the same path and walks a distance FC equal to 300 metres.

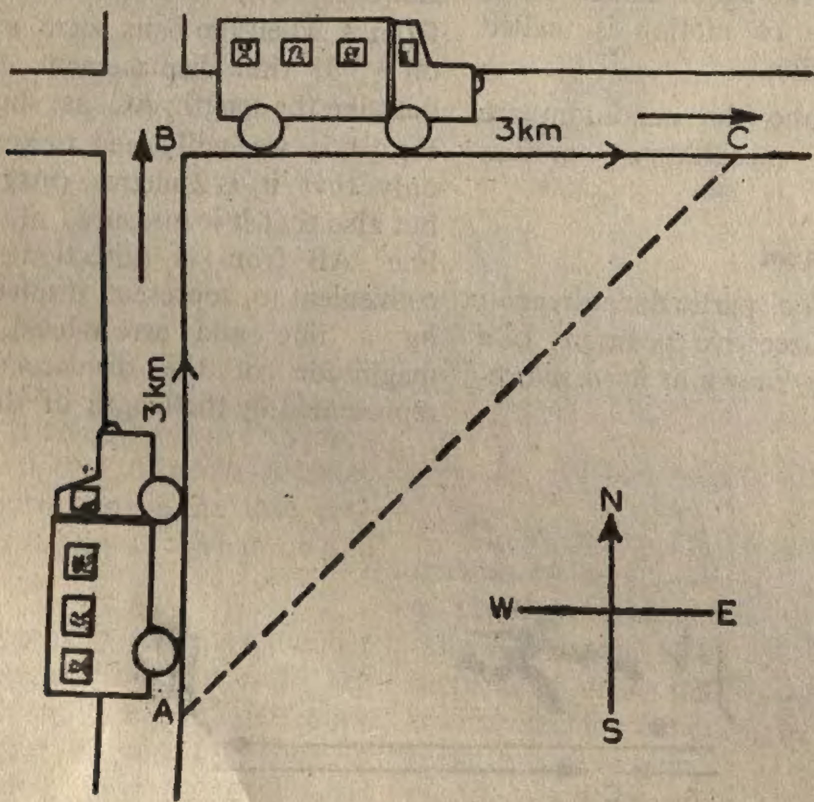


Fig. 1.7.

The result of those two trips is the same as if he had made a single trip from A to C. It means,

$$\vec{AF} + \vec{FC} = \vec{AC}$$

This addition is not a simple addition. If it were so, we would get a distance of 500 m. +300 m =800 m. From the Fig. 1.6, we see that trip FC represents a negative number because its direction is opposite to the direction of AF. Taking into consideration the direction in which the movement takes place, we get the correct answer :

$$\vec{AF} + \vec{FC} = \vec{AC}$$

$$500 \text{ m} + (-300) \text{ m} = 200 \text{ m}.$$

To describe the trip properly, we have not only to mention the distance travelled but also the direction in which the motion has taken place. In actual practice, all motions may not take place in one direction. As shown in Fig. 1.7 a bus starts from A and moves a distance of 3 km north towards B. After reaching B, the bus turns east and moves another distance of 4 kms so as to reach a point C as shown in Fig. 1.7.

In this case bus started from A and after two trips AB and BC reached the point C. This is equivalent to a direct trip from A to C.

$$\vec{AB} + \vec{BC} = \vec{AC}$$

The addition of trips is a different kind of addition from adding numbers. Here the displacement is less than the distance actually travelled by the bus which is (AB+BC). *If two vectors are joined, tip to tail, in a straight line, their resultant is represented by a line from the tail of the first to the tip of the second.*

1.3. Uniform and Non-uniform Motion

From our experience of riding a bicycle, we know that it can go slow or fast. If we pedal at the same rate and are going on a straight level road, we will cover the same distance in the same time.

We also see that on straight, level roads, the bullock-cart goes at the same rate.

When a train starts from a station, it moves slowly. After sometime, it runs fast. As it approaches another station, it slows down before stopping.

Similarly, a city bus starts slowly from a bus stand, then moves fast. When the next stop approaches, it slows down and stops to pick up more passengers.

From these examples, we can see that the motions of the train and the bus are not the same for all times.

The bicycle, the bullock-cart, the train and the bus give us some idea of motion and time.

When a body moves through equal distances in equal intervals of time, it is said to be in uniform motion.

Suppose a train covers 20 m in one second and next 20 m also in 1 sec and next 20 m again in 1 sec and so on then its motion is said to be uniform. The moon is in uniform

circular motion as it goes round the earth in the same time of $29\frac{1}{2}$ days. Similarly, an electric fan and potter's wheel go round in uniform circular motion.

Activity 1.2 :

Take a small trolley which can move freely on a smooth white paper on the table. A pulley is fixed at one end of the table. A string fixed to the trolley passes over the pulley and carries a weight at the other end. A smell bottle fitted with a stop-cock is filled up with ink and is kept on the

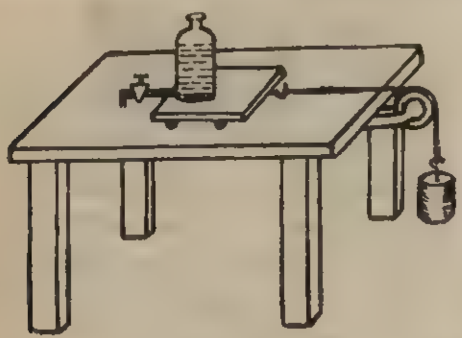


Fig. 1.8.

table as shown in Fig. 1.8. Adjust the weight in such a way that the trolley starts moving after it is pushed with a small force. Open the stop-cock slightly. Drops of ink will leave mark on the white paper.

Measure the distance between these successive drops of ink. What do you conclude ?

Activity 1.3 :

Repeat the experiment of activity 1.2 by adding some more weight so that the trolley does not require any path to start the motion. Measure the distance between these successive drops of ink. What do you conclude ?

In activity 1.2, the distance between the drops of inks remains the same and the motion of the trolley is said to be uniform. In activity 1.3, the distance between the drops of ink does not remain the same and so the motion is said to be non-uniform.

In everyday life we frequently experience non-uniform motion such as motion of a train or car when it starts or stops.

Any object that moves through an equal distance in any equal intervals of time is said to be in **uniform motion.**

When a body moves over unequal distances in equal intervals of time, it possesses **non-uniform motion.**

1.4. Speed

Some objects move slowly while some others move fast. A man, on the average, takes 15 minutes to cover a distance of 1 km whereas a cyclist covers it, on an average, in five minutes while a car, which moves faster, may hardly take two minutes to cover the same distance. Thus, to describe any motion, we find out how fast the motion takes place. For this, we have to measure not only a given distance but also the time taken to cover that distance.

The distance travelled in unit time is called **speed.** In case of uniform motion, the speed of a body can be determined by measuring the distance through which a body moves in a fixed

intervals of time.

$$\text{speed}=\frac{\text{distance covered}}{\text{time taken}}$$

If we denote the distance by d, time by t and speed by v, we have

$$\boxed{v=\frac{d}{t}}$$

Example :

A motor car travels uniformly through 180 km in 5 hours. Find out the speed of the car in km/h, m/min and cm/sec.

(*i*) $v=\frac{d}{t}=\frac{180\text{ km}}{5\text{ h}}=36\text{ km/h}$

(*ii*) $v=\frac{36\text{ km}}{1\text{ h}}=\frac{36\times1000\text{ m}}{1\times60\text{ min}}$

$=600\text{ m/min}$

(*iii*) $v=\frac{600\text{ m}}{1\text{ min}}=\frac{600\times100\text{ cm}}{1\times60}$

$=1000\text{ cm/sec}$

$=10\text{ m/sec.}$

The speed can be expressed in either of the *units*, such as cm/sec, m/min, km/h etc.

A car moves uniformly with a speed of 10 m/sec. It means that the car moves through a distance of 10 metres in one second. The distance covered by the car at the end of the next second will be 20 metres.

It means that :

In 1 second the distance travelled $=10$ metres.

In 2 seconds the distance travelled $=10\text{m/s}\times2\text{s}=20$ metres.

In 3 seconds the distance travelled $=10\text{ m/s}\times3\text{s}=30$ metres.

In 4 seconds the distance travelled $=10\text{ m/s}\times4\text{s}=40$ metres.

Thus, the distance travelled by the car in 10 seconds will be $10\text{ m/s}\times10\text{s}$ $=100$ metres. In order to find out the distance travelled by the body in a definite time, one has to multiply the speed by time.

$$\boxed{\begin{array}{c}\text{Distance}=\text{speed}\times\text{time}\\ d=v\times t\end{array}}$$

Example :

A pedestrian has a speed of 50 m/min. He reaches home after 3 hours. Find out how much distance has travelled.

$$s=v\times t$$

$=50\text{ m/min}\times(3\times60\text{ min})$

9,000 metres

$=9$ km.

1.5. Velocity

While discussing speed, we did not consider the direction in which the motion took place. If we consider the direction with the speed of the body, we have a new quantity called **velocity.** Velocity does not only tell us how fast the object is moving but also the direction in which it is moving. Velocity like displacement, is a *vector quantity.*

1.6. Inertia

The objects we see around are either at rest or in some kind of motion. A book on the table, a bed in the house, a chair in the class-room are examples of bodies at rest. A rolling ball, a stone thrown up, a satellite moving around the earth are examples of bodies in motion.

You know that in order to make an object move from its state of rest, you have either to push it or pull it or in some way apply a force on it. To move a heavier body you have to apply a greater force. If an almirah is full of books, even though you exert a large force, it does not move sometimes.

A cricketer hits the ball and it is in motion. A fieldsman stops the motion of the ball by putting his hand. Effort has to be applied to stop the moving ball. A moving cyclist applies brakes to stop the motion of a cycle.

When a cycle is moving and the road is very smooth, the cycle moves some distance without moving the pedals before it stops. Similarly, if the floor of the room is very smooth, a rolling ball moves to a longer distance before it comes to rest.

The property of everybody to continue in its state of rest or in uniform motion in a straight line is called **inertia**. It is a property common to all bodies in nature. Inertia becomes more obvious when a body is suddenly set in motion or stopped or its direction of motion is changed.

We can understand this property of inertia by everyday examples.

A person sitting in a stationary car feels a backward jerk on the upper part of his body when the car starts suddenly. If the car stops suddenly, the upper portion of the body of the person is thrown forward. This is because the person, due to inertia, continues to remain at rest when the car starts suddenly and hence the backward jerk. In case of a moving car, the body continues to move even when the car comes to rest and hence the forward jerk. A person getting down from a moving bus is likely to be thrown forward. This is because his upper part continues to move along with the bus whereas his feet are abruptly brought to rest on touching the ground.

Activity 1.4 :

Put a piece of cardboard on a jar, with a coin placed over it. Now move the cardboard suddenly with a sharp movement of your hand as shown in Fig. 1.9. What do you observe ? How do you explain this observation ?

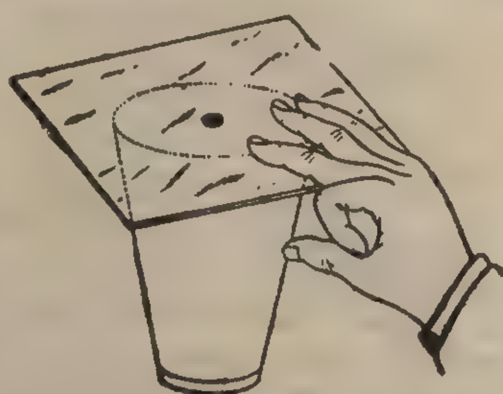


Fig. 1.9.

Activity 1.5 :

Set a pile of 10 to 15 twenty paise coins. Strike one of them quickly near the bottom. Explain what you observe ?

1.7. Mass

We have seen that a force is necessary to set a body in motion or

to stop a moving body or to change its motion. A greater force is needed to move a heavy almirah than a light chair. If we throw a cricket ball, it moves faster but if we throw a shot-put ball with the same force, it does not move quickly.

Every body in nature possesses inertia. *The mass of the body determines the amount of inertia.* The bigger the mass of a body, the greater is its inertia. It is the mass of the body at rest which determines the amount of effort required to move that body. The larger the mass, the greater is the effort. Similarly, it is more difficult to stop a loaded wagon than an empty one.

There is a close relation between the mass and weight of a body. *Mass is the amount of matter a body contains.* Mass never changes no matter where it is. Weight, however, varies, depending upon the mass of the object and its distance from the centre of the earth. It is the pull of the earth on a body. The greater the mass of an object, the greater is its weight. The farther an object is from the centre of a planet, the less it will weigh.

If the pull of gravity is counterbalanced or equalled by an opposing force the object will be weightless. Space-ships, revolving around an object in orbit, become weightless when their speed of revolution equals the pull of gravity on the object.

The weight of an object can be determined with a spring balance while the mass is measured with the help of a beam balance. The unit of mass is *kilogram* whereas that of weight is *Newton* or *kilogram weight.*

1.8. Friction

If you roll a ball on the ground, it stops after covering some distance. We have seen that whenever a body is made to move over the surface of another body, it does not have a free motion. It means that there is a force acting on the moving body which stops the motion of the body.

This force which resists the motion of a body moving over another body and acts in a direction opposite to the direction of motion of the body, is called *the frictional force.* It can be either useful or harmful.

Useful Friction

Without friction we could not walk or stop machines, bicycles or automobiles. The automobile stops when we step on the brakes. Frictional force between the tyres and the road puts the car in motion. Friction between a meteor and the molecules in our atmosphere cause most meteors to burn up before they reach earth.

Harmful Friction

Everytime we try to push or pull something, the force of friction opposes us. Friction causes the moving parts of a machine to wear out. Lubricants, bearings and smooth surfaces reduce this harmful force.

Static Friction

Activity 1.6

Take a rectangular block of wood

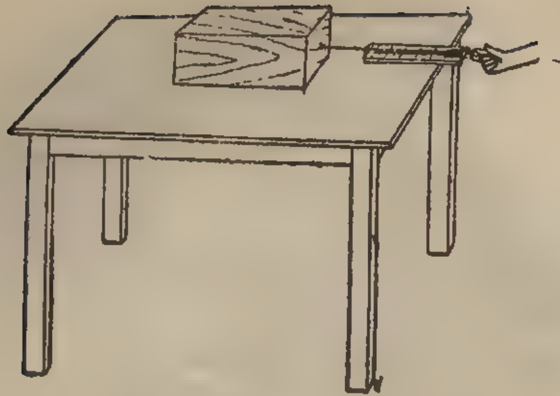


Fig. 1.10

having a hook fixed on one of its faces. Place this block lengthwise such that it is in contact with the table top. Connect a spring balance to the hook of the wooden block as shown in Fig. 1.10. Pull the spring balance. Does the block slide ?

If it does not, pull the balance more till the block begins to slide. Note the reading on the spring-balance. Why does the block slide ?

The above experiment shows clearly that when you pull a block of wood, there are two forces acting in opposite directions, the one with which you pull the body and the other, the frictional force, which opposes the motion of the body. When your pull is greater than the frictional force, the body begins to move. When the pull is very small, the body does not move because your pull is not strong enough to overcome the friction. As you increase the pull, the frictional force also increases and balances your pull but the frictional force cannot increase beyond a certain value. If you pull with a force greater than that of friction, the body moves.

The maximum force of friction that comes into play when one body *just begins* to move over the surface of another body is known as **static friction.**

Sliding Friction

Activity 1.7

Attach a string around a book as shown in Fig. 1.11 and attach the spring-balance to the string.

Applying a constant pull to the spring-balance obtain several readings of the force necessary to start the

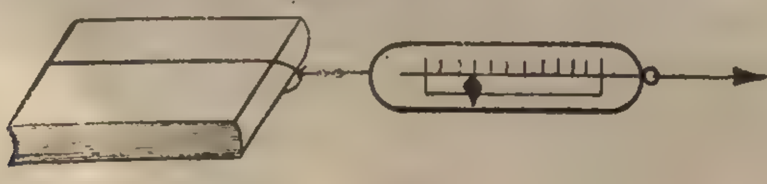


Fig. 1.11.

book in motion. Compare the magnitude of the applied force to the weight of the book.

Now place the book on its edge and record the force necessary to start it in motion. What do you conclude by comparing the results of the force required to put the book in motion when placed flat on the table and when placed on edge ?

Determine the magnitude of the force required to keep the book moving after it is already in motion. *The force of friction that comes into play when one body moves (or slides) over the surface of another body is known as* **sliding friction.** What do you conclude after comparing the starting friction (static friction) to the sliding friction ? Obviously, sliding friction is less than static friction.

Rolling Friction

Determine the magnitude of the applied force needed to keep the book in motion after two or three pencils are placed below the book as shown in Fig. 1.12 and record the results.

The force of friction that comes into play when one body rolls over the surface of another body is known as **rolling friction.**

In the above activity, you have seen that to set a body in motion you require more force than to keep that body in motion. It means that static friction is more than sliding friction. When the body was rolled, the force required to keep the body in motion was the least. It means that rolling friction is less than sliding friction. That is why we use ball-bearings in machines to reduce friction. They consist of small balls, made of steel placed between two surfaces.

Friction can be reduced to 1/20th of its original value by using ball

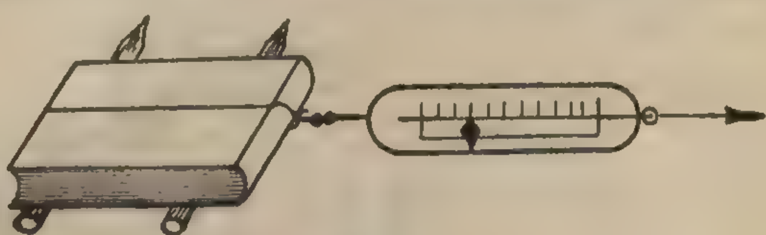


Fig. 1.12.

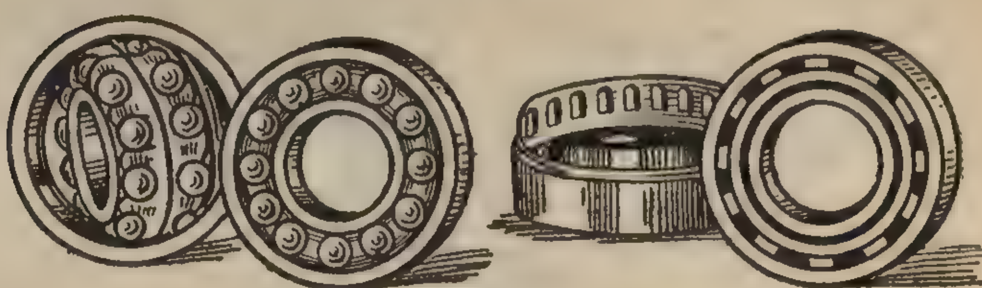


Fig. 1.13.

bearings in motor cars, electric motors, cycles, etc.

Activity 1.8

Take three small boxes of the same size and shape. Mark them A, B and C. To the bottom of box A, glue a sheet of sand-paper. To the bottom of box B glue a piece of cloth and to the bottom of box C, glue a piece of smooth paper. Now fill all three boxes with the same amount of sand. Fasten one end of a piece of string to each box in turn and the other end to the hook of the spring balance. Note down the force required to start the boxes moving. What do you conclude ?

From the above two activities, we conclude that coefficient of friction between two surfaces does not depend upon the weight of the moving body but upon two factors only :

(*i*) the material of the bodies in contact,

(*ii*) the roughness of the surfaces.

A force of friction acts in a direction opposite to that in which a body moves and acts parallel to the surfaces in contact.

1.9. Action and Reaction

Activity 1.9

Whenever a body A exerts a force on another body B, the body B will also exert an equal and opposite force on the body A. The force exerted by body A on body B is called **action** and the equal and opposite force exerted by the body B on the body A is called **reaction.** Consider a book lying on the table. The weight of the book presses the table downwards and that is known as an *action.* The table in turn presses the book upward. The force applied by the table is known as *reaction.*

Take a rubber balloon. Fill it with

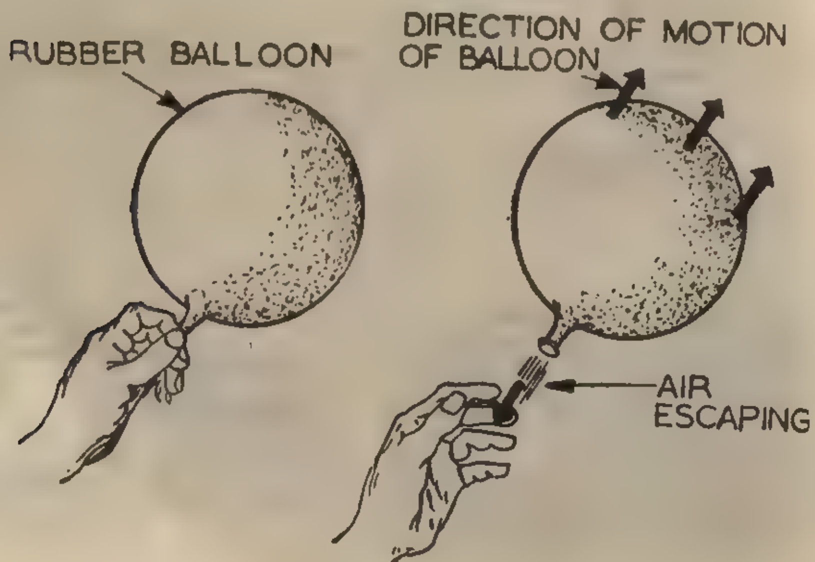


Fig. 1.14.

air. Hold it with its nozzle downwards and then suddenly release it. Where did it get the force to go upward ?

In this case, the air inside the balloon, while coming out, exerts a force due to which the balloon moves in the opposite direction.

Activity 1.10

Take two spring-balances. Attach the hook of one spring balance to the hook of the other spring balance. Pull each of these spring balances and note the readings of each of the balances. What do you conclude ?

Activity 1.11

Fix one of the spring balances to a hook in the wall and pull the other balances. Note the reading of both these balances. What do you conclude ?

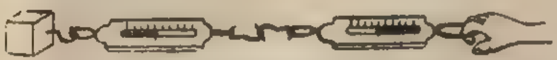


Fig. 1.15.

In both these activities, the spring-balances register exactly equal pulls indicating that the pull exerted by the hand on the wall, which is action, is equal and opposite to the pull exerted by the wall on the hand, which is reaction.

Thus, we see that when one body exerts a force on another body, the second body also exerts a force on the first body which is of the same magnitude but acts in the opposite direction.

To every action, there is an equal and opposite reaction. This was first stated by the great scientist, Sir Issac Newton. There are many illustrations of this law :

(1) When walking on the ground, we exert a force over it by our foot and as its reaction, the ground pushes our body forward.

(2) In a steam boat, the steam is thrown by a jet backwards and thus the reaction of the steam pushes the boat forward.

(3) A jet plane or a rocket is pushed forward by the reaction of the escaping gases which is thrown out of the jets in the rear of the plane.

(4) When a person gets down from a boat and jumps suddenly, the boat moves backward while the person moves forward.

1.10. Thrust and Pressure

Vehicles are prohibited over some pedestrian bridges. One might say that a vehicle is much heavier than a man, as such the structure of the bridge might crash under its weight. True it is, but, as is often the case with such bridges, the number of persons passing over the bridge at a certain instant, together might weigh much more than a single vehicle, yet it does not crash under their weight. Why ?

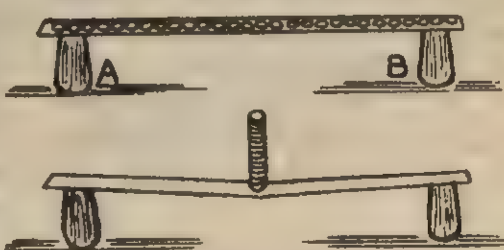


Fig. 1.16. Strip bends when coins are placed one over the other.

Let us try to understand the problem by scaling it down to a simple experiment. Place a wooden strip over two similar supports, say glass tumblers. Place a number of 10 paise coins side by side over the strip. It may take as many as 30 or 40 coins to cover the strip from one end to the other, yet it may not bend appreciably under them. Now try to place them one over the other somewhere in the middle of the span and watch. Bending of the strip starts even under the weight of half the number of the coins and if the strip is not strong enough, it might break if all the coins, which were spread over its entire, length, are put together.

Now let us analyse what happened. When the coins were spread over, the total downward force on the strip due to their weight was the same as it would have been if they were placed at one point. But in the first case it was distributed over its entire span so that the force on the area under one coin was only equal to the weight of a single coin, but in the latter case the force over that area was increased many fold which caused the bend in the strip ultimately crashing it.

In case of the vehicle the weight is concentrated over a smaller area while the persons who cross the bridge are spread over the entire span ; as such it does not crash under that weight. If all the persons collected together at one spot, the effect would be otherwise.

This clears up one very important fact that effect of force depends upon the area over which it acts. To differentiate between the total force acting on a body and the force acting per unit area we have, therefore, to use two distinct terms.

Total force acting over a body is called the THRUST. Thrust can be expressed in the unit as force is expressed, *i.e.* in; dynes or grammes weight etc.

Force acting over a unit area is called the PRESSURE. We can say that pressure is the thrust per unit area.

Pressure is, therefore, expressed in units of force per unit of area.

If a bucket of water is filled with 5 kg of water and has a base area of 500 sq. cm then the pressure on the base

$$=\frac{5000}{500}$$

$$=10 \text{ g wt. per sq. cm.}$$

Some other units commonly used to express pressure are the following :

kg/m^2—kilogram wt. per. sq. metre
kg/cm^2— „ „ „ centimeter
$Dynes/cm^2$—Dynes per sq. centimetre.

$Newtons/m^2$—Newtons per sq. metre

We often speak of pressure as so many grammes. What we really mean is so many grammes per square centimetre as generally it is understood in the common language. Hence we shorten our expression by omitting the words per square unit area.

It should be borne in mind that the corresponding units of area and

pressure must be consistent. If area is expressed in sq. cms the pressure must be in gms wt. or Dynes per sq. centimetre.

Where thrust is uniformly distributed over a surface, we can always work out the pressure by the following relation :

$$\boxed{\text{Pressure} = \frac{\text{Thrust}}{\text{Total area}}}$$

Thus, if we place a metal cube with sides 10 cm. each and its weight is 10 kg. on the table then its thrust is 10 kg. wt., while pressure is $\frac{10}{10 \times 10}$

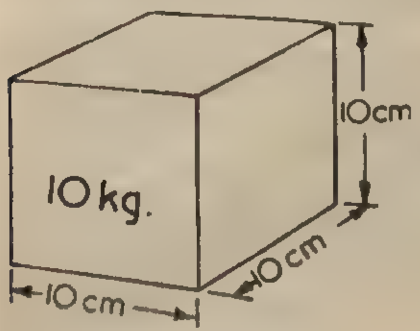


Fig. 1.17.

i.e., 1 kg. wt. per sq. cm. and it is uniformly distributed.

But if there is heap of sand, also 10 kg. in weight, it will exert the same thrust of 10 kg. wt. over the table but since it is not uniformly distributed its pressure is not 1 kg/cm² as in case of the metal cube but it varies from point to point, depending upon the matter over each point.

In such cases we do not deal with pressure per unit area but we very often speak about the pressure at a point which is equal to the thrust over a very small area surrounding the point divided by the area.

The difference between pressure and thrust can be made clear by the following more typical examples from our daily life.

(1) Take a heavy vessel, say a big lota full of water and place it over a small pointed stone placed over your palm on the table. It hurts.

Repeat the same experiment but this time, instead of the pointed stone place a flat piece of wood, say 2 sq. cm. in area, on your palm. It hurts less.

Repeat the same experiment again, now placing a soft cloth pad ring to place the lota on your palm............... this time it is the least uncomfortable. That is why the porters use cloth pad

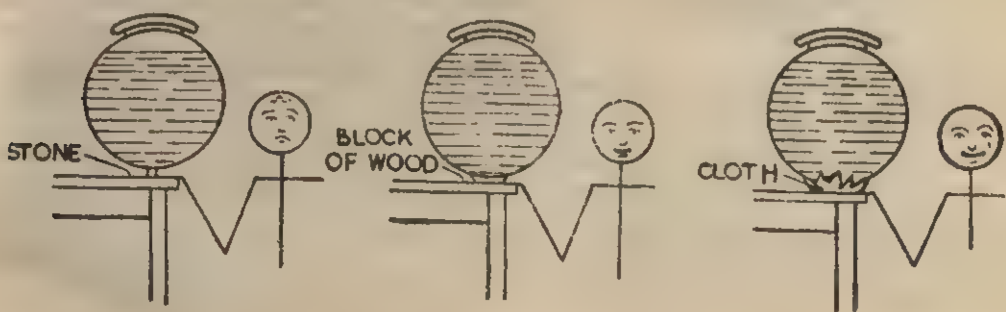


Fig. 1.18.

rings when they lift the loads on their heads.

Fig. 1 19

(2) A knife is able to cut through an apple because the thrust of the hand exerts very large pressure at the edge, the edge being very narrow. The cut over the area, consequently is very narrow. The cut over the area is consequently very narrow.

Fig. 1.20.

(3) Heavy buses and trucks have double wheels and broad tyres. The area of the road upon which these vehicles rest, therefore, becomes large, reducing thereby the effective pressure on the tyres. Had the wheels been single and with narrow tyres, the pressure due to the thrust of the vehicle would have been large enough to burst them.

(4) Steel plate belts are provided under the wheels of heavy tanks and tractors to increase the effective area, consequently to reduce the effective pressure of the thrust of the vehicle so that it could conveniently move forward even on softer ground.

(5) Iron rails of the railway track are fixed over large, and wide wooden or steel sleepers to reduce the effective pressure of wheels due to enormous thrust of the train's load, thus preventing them from getting buried into the earth.

Fig. 1.21.

(6) While walking over the soft earth, say on the wet bank of a river high heels sink deeply into the earth because of the great pressure exerted due to the thrust of the body. The heels of some one walking bare foot make only a slight impression. The thrust in the later case being equally distributed.

It is not necessary that the force acts only in the downward direction. As a matter of fact forces do act in all directions and consequently thrust can be effective in all directions. So far we have seen the thrusts due to

the weight of the bodies.

Fig. 1.22.

A drill moves in the horizontal direction when the carpenter exerts the thrust to bore a hole in the door or window frame.

Pressure in Fluids

We have so far seen thrust, and pressure and their effects in case of solids only. Thrust and consequently the pressure are exerted by liquids as well as gases. Rather, the effect is more prominent in them and hence needs special study. We shall deal with fluid pressure in the rest of this chapter. First we will take up the liquids.

Thrust caused by the liquids

Almost all of us have had an experience of getting ourselves in and under water in a river, or a swimming tank or even in a bathing tub and have experienced the thrust that the liquid exerts over our body. As we go deep in water this thrust is felt increasingly, hence the thrust is caused by the weight of the water. But there is one peculiar thing which we did not normally experience in solid that the thrust is not downwards alone, but presses our body from all directions. We shall now observe and try to study this formally.

Let us first prepare an instrument which will indicate the effect of a thrust. We know that liquids keep their level. As such if we fill in water in a U-tube, its level will be the same in both arms. Clamp such a tube on a stand, against a graduated board and attach a rubber tube to one arm. On the other end of the rubber tube attach a small funnel, the mouth of which is closed by stretching a piece of rubber over it. Our thrust detector is now ready. Press the stretched rubber diaphragm with your finger, this thrust on the rubber diaphragm will

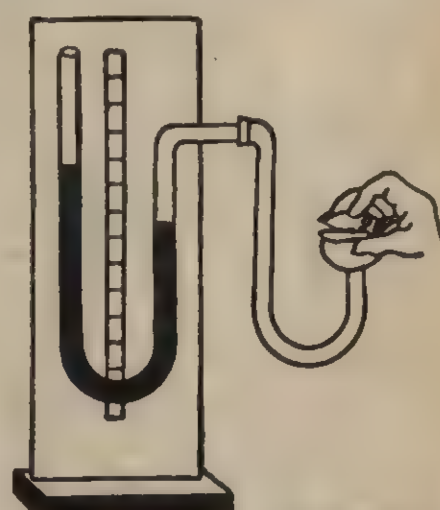


Fig. 1.23. The manometer

push the water in the limb of the U-tube and it will rise in the other limb. The difference in the two levels will be the indicator of the thrust. This is likewise the indicator of the pressure also on the diaphragm because the area of the diaphragm

daes not very much change ordinarily. This simple pressure detecting instrument is called the MANOMETER.

Let us now examine a liquid at rest, say water filled in a vessel. Since the liquid is at rest, forces acting on every particle of it are balanced, irrespective of its position. Hence the pressure at any point in the liquid is the same in all directions. Let us verify it with our manometer. Bring the diaphragm funnel inside water and look at the levels in the two limbs of the manometer. The level in one goes down and rises in the other as the funnel is taken lower and lower, but if it is held at the same depth

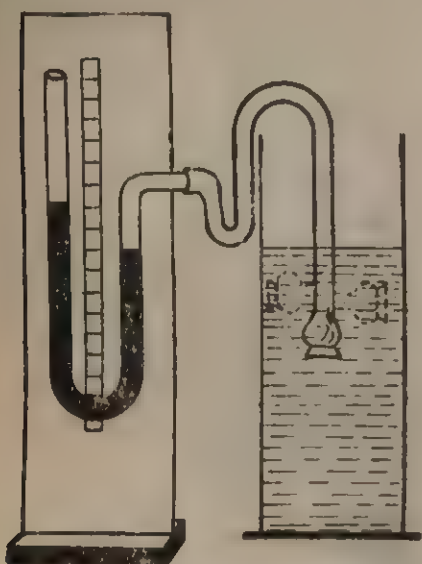


Fig. 1.24.

and its position or merely direction is changed no effect is indicated on the manometer.

This means (*i*) Pressure of a liquid increases with its depth (*ii*) At the same depth, the pressure is the same at all points (*iii*) At any point, the liquid pressure is the same in all directions.

Let us perform some more experiments to confirm these findings.

Take an empty tin can and pierce 3 holes of equal bore one above the other vertically, and cover them with cellotape to be opened at will. Now fill the can upto its brim and remove the cellotape to open the holes. Why should the water from the lowest hole go farthest ? Only because of the largest pressure which exists at the greatest depth and consequently the pressure is least at the least depth. This confirms our first finding—pressure increases with the depth.

Fig. 1.25. Pressure increases with the depth

Take another similar can and this time pierce several holes at the same height and repeat the above experiment. Why should the water go to equal distances from all the holes ? Simply because this time the pressure at all points is the same. This confirms our second finding *i.e.*, pressure is the same at all points at the same depth.

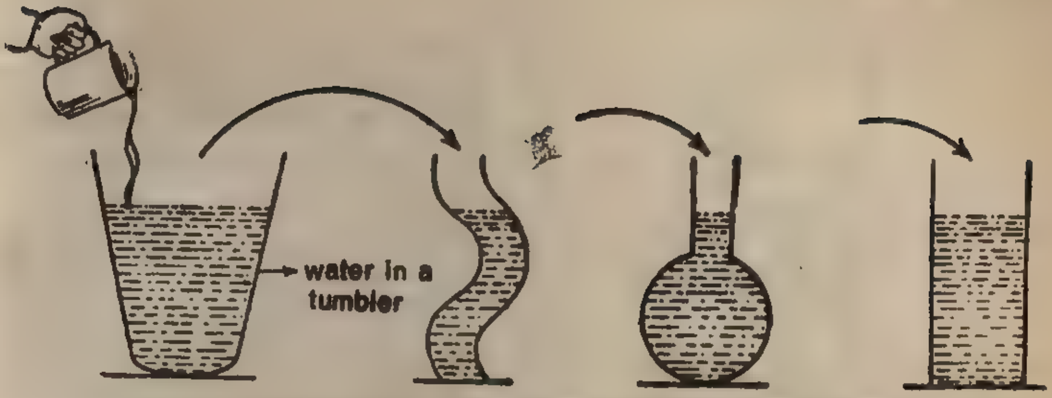


Fig. 1.26. Shape and size of vessel have nothing to do with pressure

It is this pressure and consequently the thrust, that is felt by us when we go into the water of a pond or a swimming tank from all directions. The side-ways pressure is also exerted on the walls of the container and this goes on increasing as we go on going deeper and deeper into the liquid.

The pressure (p) of a liquid at a certain depth (h) is the product of the depth, its density (d) and the acceleration due to gravity (g).

We may write this as

$$\boxed{p = h\ d\ g}$$

The area of the vessel, its shape and size have nothing to do with the pressure of the liquid in it. It only depends on its depth, provided the density remains the same at all depths.

This fact can be verified by taking vessels of different shapes and sizes and measuring the pressure at their bottom when they are filled with the same liquid and up to equal heights. Our pressure detector we have already made, could serve the purpose well. Here, we attach separate manometers to the vessels but they indicate the same pressure. In place of manometers we could use the pressure gauge or any other device.

This clearly explains why liquids should stand on the same level if the vessels are joined together at the bases. Because the pressure of the liquid columns will be the same at

Fig. 1.27. Liquid stands on the same level

the bases, there will be no tendency to flow even on joining them. That is the reason why a liquid always seeks its level—the principle on which the city water supply is based. The water reservoir is placed at a level higher than any house. Water reaches the highest houses in its effort to seek its level.

As the pressure of the liquid increases with its depth, it causes an enormous thrust over the deep sea.

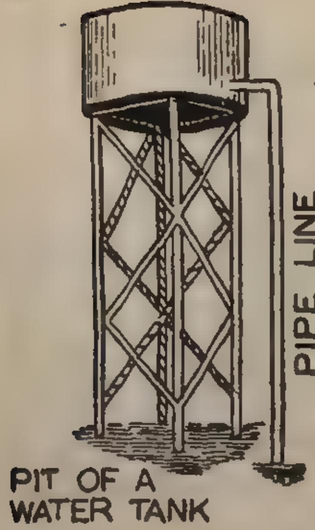


Fig. 1.28. Water reservoir at a high level.

divers. The diver will be crushed under this thrust if he does not put on his diver's suit. This is made of such material as can withstand the enormous pressure of water. When the diver goes deep into the sea, he is supplied air to breathe through tubes connected with the boat from which he dives into the sea.

We have so far considered only one factor on which the pressure of the liquid depends, that is depth. Looking into the expression

$$p=h \times d \times g$$

we see that the pressure will change if the density of the liquid changes, *i.e.*, if we have similar vessels and fill these with different liquids upto the same height, the pressure will not be the same at their bottoms as indicated by the manometers.

As the pressure increases with the depth, consequent thrust also increases as we go deeper and deeper ; it is, therefore, obvious that the lower portion of the dam walls is required to withstand larger pressure than the upper one. Hence, it is necessary that the walls should be much wider at the base than at the top.

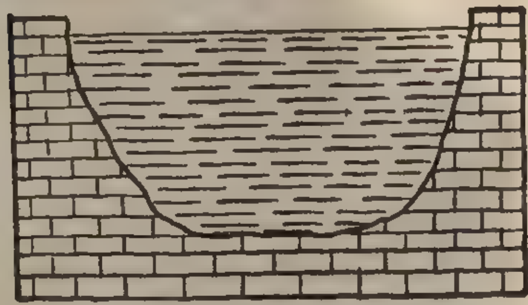


Fig. 1.29. Section of a dam to show that the walls are wider at the bottom.

1.11. Buoyancy (Archimede's Principle)

It is the experience of the sailors at sea that it becomes difficult to lift the heavy anchor of the boat when it is out of water.

Similar is the experience of the boatmen when they row the boat. Oars are felt heavy when they are out of water.

We can also recall that the lota becomes heavy when it is taken out of

Fig. 1,30. Oars are felt heavier when out of water.

the bucket full of water. Why are the objects felt to be heavier when they are out of water than when inside it ?

More than 2,000 years ago, an old philosopher in Greece was also confronted with similar experience. One day, he entered the bathing tub full of water. He noticed that as soon as he entered the tub, a lot of water was spilled out and he felt his body to be much lighter. This made the old philosopher think. Why should the water flow out ? Why should he feel lighter ? Is there any relation between the two ?

He persued this chain of thought and conducted some experiments which we will repeat here for ourselves and see if the two phenomena of over-flowing of water and feeling of lightness are related.

Activity 1.12.

To find the amount of water displaced by a body when immersed in water :

Take an OVER-FLOW or EUREKA vessel and fill it with water. Place a previously weighed beaker under the side tube. Take the object (say, a glass stopper), tie it to a thread and lower it into the overflow vessel. Note what happens. The water displaced by the object over-flows into the beaker. Weigh the beaker again to find the weight of the water displaced by the object.

What relation does the volume of water displaced have to the volume of the object ? They are equal.

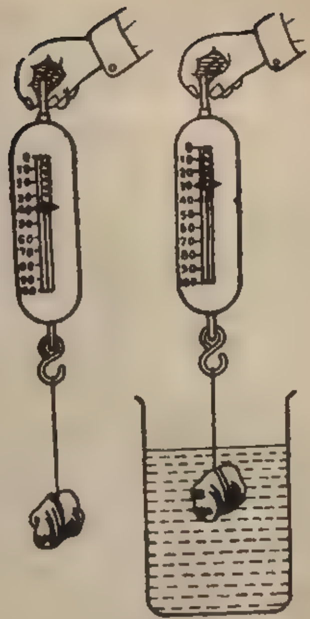


Fig. 1.31.

Now, repeat the experiment but, this time suspend the object from a spring balance. Note and record its weight. Lower it into the over-flow vessel keeping your eyes on the indicator of the balance. Note that it moves up thereby showing a decrease in weight. When the object is completely submerged and suspended in water, note its weight again. See that it does not touch the vessel anywhere. Find how much the object loses in weight when submerged in water. Compare the loss in weight to the weight of the water displaced by the object. You will find that the two are equal.

Repeat the experiment again, this time placing the beaker on one spring balance and suspending the object from another.

Now let us immerse this object

into the water of the over-flow vessel, and note the difference in the two balance. It will be found that the suspension spring balance registers a decrease in the weight of the solid which is exactly the same as the increase in weight of the beaker due to the water collected in it, as shown by the balance on which it is placed.

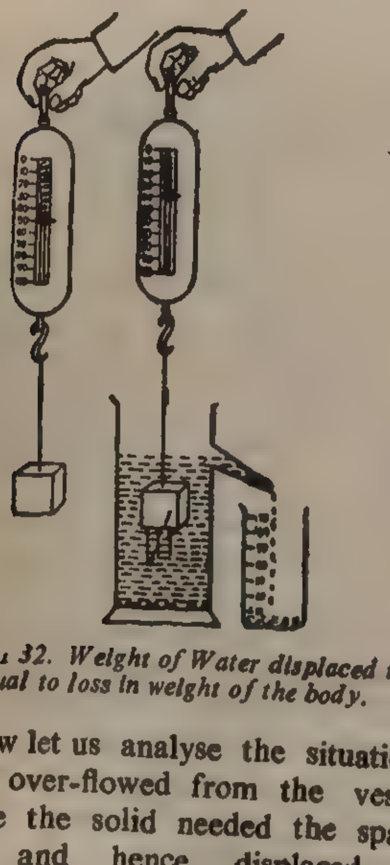


Fig. 1 32. Weight of Water displaced is equal to loss in weight of the body.

Now let us analyse the situation. Water over-flowed from the vessel because the solid needed the space inside and hence displaced it. Naturally, the displaced water is of equal volume to the solid itself. The weight of the solid was decreased because the water exerted an *upward force* called *buoyancy* on it, as we have already learnt it does. And hence, the resultant downward force, *i.e.*, the decrease in weight is equal to the upthrust.

The weight of water collected in the beaker is observed to be equal to the decrease in the weight of the solid. This shows that the upthrust is equal to the weight of the water displaced.

This experiment may be repeated with different liquids. The decrease in weight is always found to be equal to the weight of the liquid displaced.

If you go on repeating these experiments using different objects and weighing them in different liquids you will find that :

1. If solids of different materials which are equal in volume, are taken the loss in weight in the same liquid is always the same.

2. The loss in weight of a solid, double in volume, is double. irrespective of the material of the solid, *i.e.*, the loss in weight depends directly on the volume of the solid and not on its material.

3. The loss in weight of the same solid changes in different liquids *i.e.*, the loss in weight depends on the density of the liquid.

We can, therefore, generalise our observations, as the philosopher Archimedes did :

When a solid is immersed in a liquid, it experiences a loss in its weight. This loss in weight is equal to the weight of the liquid displaced by the solid.

This is known as the PRINCIPLE OF ARCHIMEDES.

It will be interesting to know that

Archimedes discovered this principle accidentally while he was given a serious problem to investigate. The king had given some pure gold to a goldsmith for his crown. But when the crown was ready, the king suspected that the goldsmith had cheated him, although the weight of the crown was exactly the same as that of the gold given to him. He ordered the philosopher to investigate into the purity of the material of the crown.

You know how during his bath he suddenly realised what he ought to do. He reasoned that the crown would displace its own volume of water and so would the piece of pure gold of the same weight. But the weight of water displaced, hence the loss in weight will only be equal if the material of crown was exactly the same as that of the piece of pure gold. And he actually weighed them in air and water and found that the loss in weight in case of the crown was more than that in the case of pure gold. Hence he concluded that the crown was less dense, *i.e.*, it was made of a mixture of metals lighter than gold. Silver or copper might have been mixed in gold to make up the original weight.

If we immerse a cork under water and release it, it rises and floats on the surface. Similarly if we release a balloon filled with hydrogen, it rises in the air. When we draw water from a well, we find it easy to pull the bucket when it is immersed in water. But as soon as it comes out of the water it suddenly appears to have become heavier.

All these phenomena are due to a property of liquids and gases, called **buoyancy**.

Whenever an object is partly or completely immersed in a **fluid** (liquid or gas), *it experiences an upward force. This upward force is called the* **buoyant force.**

Animals like whales which live in water grow to an enormous size. The buoyant force of water helps them to move easily. With such enormous size, it would have been difficult to move on land. The fishes use the buoyant force of water to come upto the surface of water. They have a special organ within their body called the **air bladder**. For coming up, the fish swells the bladder and for going down it withdraws the gas. Submarines, which run in the depths of the ocean, are also designed on the principle of thrust and buoyant force. The same is true about the dresses of the divers who dive deep down into the ocean and can stay there for a certain period of time and then come up.

How can we measure the buoyant force ?

Let us take a solid body and hang it from a spring balance [Fig. 1.33 (a)]. The reading on the balance shows its weight. Suppose it is 400 gm. wt. Now dip a part of the solid body in an overflow can containing water [Fig. 1.33 (b)]. Suppose the spring balance now reads 350 gm. wt. This

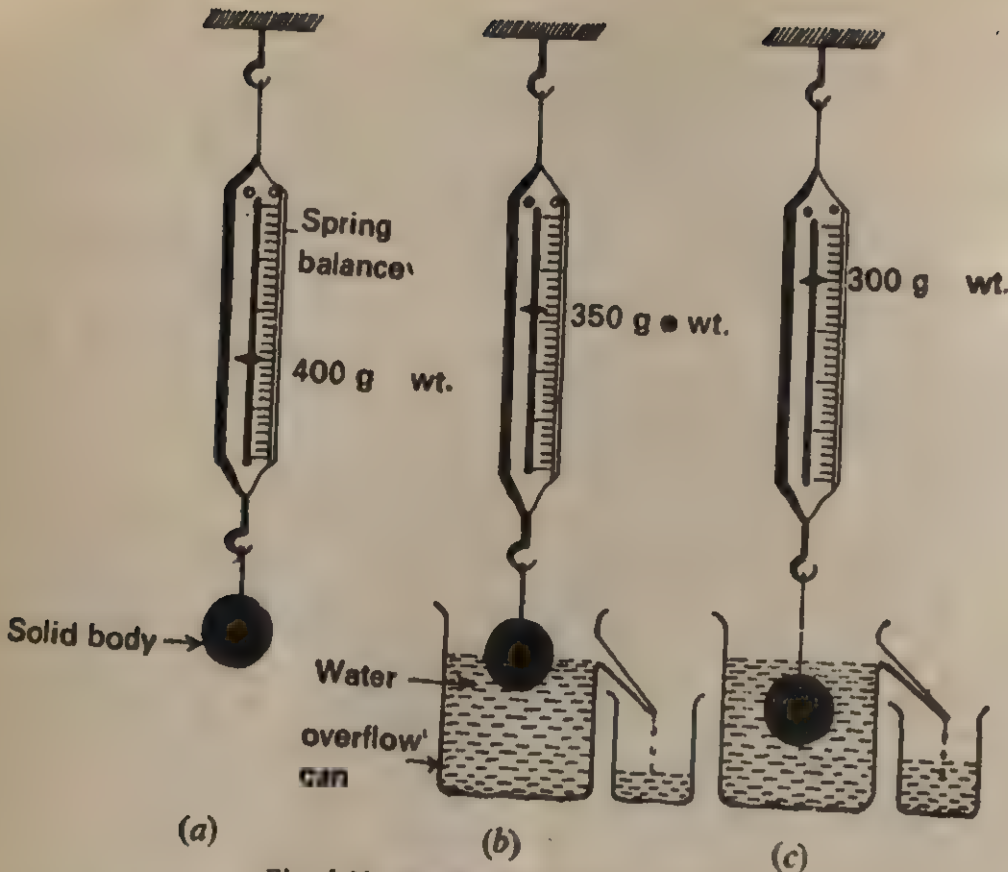


Fig. 1.33. Measuring the buoyant force

means that buoyant force is 400—350= 50 gm. wt. Let us dip the solid body completely and suppose the reading is 300 gm. wt. [Fig. 1.33 (c)]. This means that the buoyant force when the solid body is completely immersed is 400—300=100 gm. wt. You will find that dipping the solid body any further does not change the reading on the spring balance. This means that the maximum buoyant force equals 100 gm. wt.

In the above experiment, if we measure the weight of the water which overflows from the overflow can, we find an interesting result.

In each case, the buoyant force equals the weight of the water collected.

The Greek scientist, Archimedes, performed many such experiments with different liquids and was led to the following conclusion :

A body which is partly or completely dipped in a liquid experiences an upward force. This force is equal to the weight of the liquid displaced. This is known as **Archimedes' Principle**.

1.12. Pascal's Law

It is an interesting sight to see a heavy car being lifted over a column coming up from the ground in an

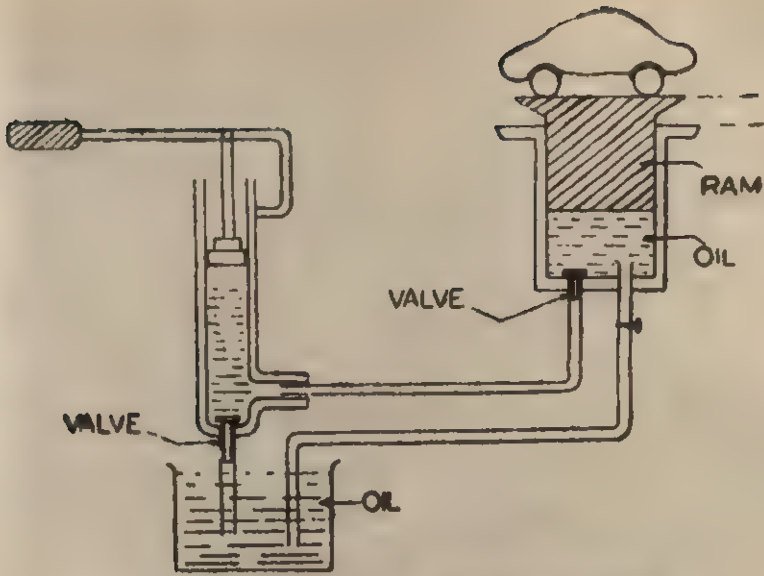


Fig. 1.34. A heavy car being lifted over a column

automobile workshop. This is done for the purpose of cleaning or repairing the machine at the bottom of the car. The weight of the car is so heavy that it cannot easily be lifted even by as many as six persons and that too to such a great height. It is quite amazing to learn that this is lifted here by a piston dipped in an oil tank on which a comparatively much smaller force is applied through a narrow pipe. How does this oil develop such a large force ?

To study this we shall have to revise our knowledge of the liquid pressure again. We have seen that if different containers are joined together at their bases and a liquid is filled into each one of them, the level of the liquid stands at the same height in all of them irrespective of their upper shapes or sizes. We have also measured the pressures at the bases of the three vessels separately and found that they are equal. That is the reason, we had assigned, that the liquids do not flow from a larger vessel to the smaller vessel. How does then the extra thrust, due to weight of the liquid in the wider vessel act ?

To answer this, let us perform a simple experiment. Take a rubber ball and pierce into it a number of small holes by means of a needle at different places. Squeeze the ball inside water and release so that the air comes out and water gets filled into it.

Take out the ball and again squeeze it at any point and observe the water jets coming out of the holes we had pierced. It is observed that water comes out with equal intensity from each hole and falls down at equal distances from the ball in all directions.

Has the pressure been equally-transmitted to all points ? It appears so because of the equal intensities of the jets coming out at different points.

Fig. 1.35. Water comes out from the holes with equal intensity

We can measure their pressures as well. Instead of a rubber ball, this time a glass spherical vessel which has several manometers attached at different points is taken. Water is filled inside the vessel. A pressure is applied to it by a piston at one point. It is observed that water in all the manometers rises equally. It shows that whatever pressure is applied at one point on the water in an enclosed

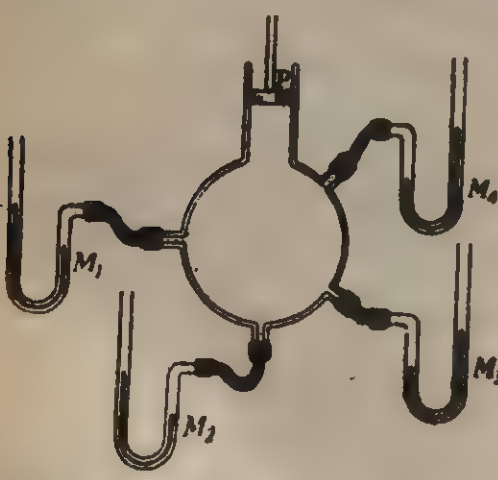


Fig. 1.36. When pressure is applied on the piston, water in all the manometers rises equally.

vessel, it is equally transmitted in all directions. Water would come out where it gets the way, and at other places the pressure simply exerts thrust at the walls of the vessel.

This also explains our problem of vessels of different sizes and shapes. Thrust due to the pressure at all points has been borne by the walls of the vessel which are strong enough to withstand it.

Let us perform an interesting experiment. Take two exactly similar flasks with just fitting rubber corks. Fill one of them with water up to the brim and cork it. The other may simply be closed by the cork. Place both of them on a rubber cushion. Give gentle blows of hammer to the cork of the one which did not have water. It is observed that the impact of the hammer pushes the cork forward into the flask and the flask does not break with this much of external impact.

Now give a similar blow to the cork of the flask containing water. With just one or two blows the flask cracks. Why do the walls shatter? In the first case the pressure pushed the cork in because the air could be compressed. In the latter case water could not be compressed, instead it transmitted the pressure of the blows equally to all the points of the walls, thus developing a thrust, much more multiplied in magnitude, causing the walls to shatter.

This fact was discovered for the first time by a scientist, BLAISE

PASCAL. Hence this principle is called *PASCAL'S LAW.*

When any part of a confined liquid is subjected to a pressure, the pressure is transmitted equally and undiminished to every position of the inner surface of the containing vessel.

If two or more vessels are connected together, they constitute one single vessel for this purpose as the pressure is transmitted equally at all points, even through the linking passage as well.

As such, if one vassel has an area of cross section ten times that of the other, the pressure applied at the surface of the liquid in the narrow tube is equally transmitted to the liquid of the wider tube. Thrust at the surface of the wider tube will thus be magnified ten times.

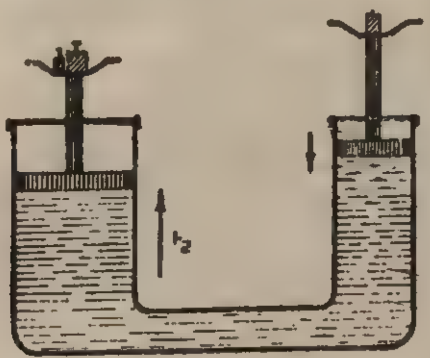


Fig. 1.37.

This also explains how a heavy car can be lifted by applying comparatively smaller force on the piston of smaller area. Such lifts are called HYDRAULIC LIFTS. Initial force is applied by compressed air at the narrow pipe and as the area of the piston on which the ram is attached is several hundred times larger, the thrust is developed several hundred times, large enough to lift the vehicle. The liquid generally used is an oil which does not freeze during winters.

This enormous force, developed due to the enormous thrust is utilised for different purposes.

1. THE HYDRAULIC PRESS. Cotton or other stuff is compressed to be tied into bales of much smaller volume by means of a press working exactly on the same principle. The ram is attached with a platform on which the cotton is heapped. It is pushed against the steel roof over-head with the enormous thrust. This press is also called the BRAMAH'S PRESS.

2. THE HYDRAULIC BRAKES. As the pressure is transmitted uniformely and simultaneously at all the points and in all directions by this device it is also utilised in the brakes of the automobiles, which simultaneously grip all the four wheels uniformally and with the same force when the lever is pushed by the foot of the driver.

3. Since heavy uniform thrust is developed, this device is also used in crushing of oil seeds and in pressing stout metal sheets to desired shapes. The body of the automobile, cars or scooters is pressed into definite shape out of the stout steel sheets under the hydraulic press.

4. Pascal's Law is utilised in simultaneous lifting and lowering of the wheels of the aeroplanes, when it

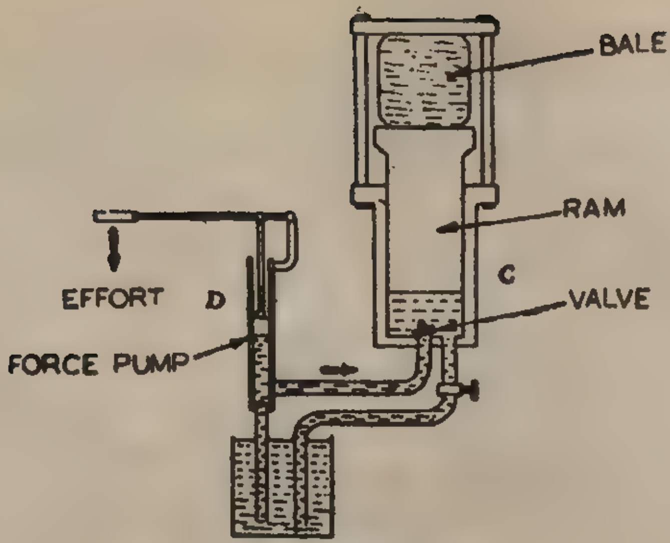


Fig. 1.38. The Bramah's Press

takes off or lands. The pressure on the same liquid also moves its wings and fans, by a little manipulation of levers by the pilot.

5. In large buildings where there are thousands of windows and ventilators, it would be very difficult to open them manually and it will take a long time to do so. By connecting the levers attached to all of them, to a pipe-line in which oil is filled pressure applied at one end can be made to open or close all of them simultaneously. This is how it is done in large buildings in western countries.

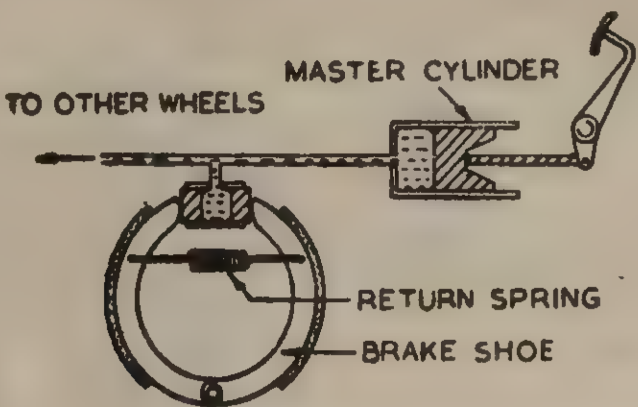


Fig. 1.39. Hydraulic brakes being applied by the driver

SUMMARY

1. The continuous change of position of a body with respect to another is called mechanical motion.

2. There are different types of mechanical motion such as translatory, rotatory and oscillatory.

3. Distance in a particular direction between two successive positions of a moving body is known as its displacement.

4. Any object that moves through an equal distance in any equal intervals of time is said to be in *uniform motion.*

When a body moves over unequal distances in equal intervals of time, it possesses *non-uniform motion.*

5. The property of everybody to continue in its state of rest or in uniform motion in a straight line is called *inertia.*

6. *Mass* is the quantity of matter contained in a body. It is measured in kilograms.

7. *Weight* is the pull of the earth on a body. It is measured in newtons or kilogram-weight.

8. *Frictional force* is a force which resists the motion of a body moving over another body and acting in a direction opposite to the direction of motion of the body.

9. When one body exerts a force on another body, the second body also exerts a force on the first body which is of the same magnitude but acts in the opposite direction. In other words, to every action there is an equal and opposite reaction.

10. Total force acting on a body is called *thrust.*

11. Force acting over a unit area is called *pressure.* It is measured in Newtons per square metre.

12. Pressure of a liquid increases with its depth ; at the same depth, the pressure is the same at all points ; at any point the liquid pressure is the same in all directions.

13. Whenever a solid is immersed in a liquid, it experiences an upward thrust which is equal to the weight of the liquid displaced by the solid. (Archimedes Principle).

14. When any part of a confined liquid is subjected to a pressure, the pressure is transmitted equally and undiminished to every position of the inner surface of the containing vessel (Pascal's Law).

On this principle we have got a number of machines in our daily life.

QUESTIONS

1. When we shake the branches of a tree, wny do the fruit or the flowers fall down instead of going up ?

2. Why is it more difficult for a bullock-cart or a truck to come to rest when it is loaded than when it is empty ?

3. Why do we say that the weight of an object becomes very much less on the moon than on the earth ?

4. Why do we put lubricating oil in a sewing machine ?

5. Why does a glass plate break when it falls on a hard ground but does not break when it falls on mud ?

6. Why does a rocket (hawai) shoot up when it is lighted ?

7. State whether the following are Vector Quantities or Scalar :
Force, mass, length, temperature, weight, volume, density.

8. Why does a bowler take a start before he delivers the ball ?

9. Why does dust from a carpet come off if it is beaten by a stick or is shaken ?

10. Why do carpenters apply grease on screws before fixing them into a wooden board ?

11. Define (*i*) Thrust
(*ii*) Pressure
(*iii*) Force of buoyancy.
Give one example in each case.

12. State (*i*) Archimedes Principle and (*ii*) Pascal's Law.
Give two examples of each.

13. Distinguish between
(*i*) Mass and Weight.
(*ii*) Uniform and Non-uniform motion.
(*iii*) Thrust and Pressure
(*iv*) Rolling Friction and Sliding Friction.
(*v*) Linear motion and Rotatory motion.

14. (*a*) Define Interia and Force. Give two examples in each case.
(*b*) Mention the units of
(*i*) Mass (*ii*) Weight (*iii*) Force (*iv*) Thrust (*v*) Pressure.

15. Complete the following statements :
(*i*) The..................of a train is larger than the..................of a car.
(*ii*) The..................of an object can be measured with the help of a beam balance.
(*iii*) ....is the unit of mass.
(*iv*) ....is the unit of weight.
(*v*) The density of a substance is independent of its.................. or..................
(*vi*) .... $= \frac{\text{Total distance}}{\text{Total time}}$
(*vii*) ....is the unit of density of a substance.
(*viii*) ....friction is always greater than..................friction.

16. Match the statements in Column A with those in Column B by drawing lines :

Column A	Column B
(a) Km/Sec	(a) are two different physical quantities.
(b) If a car speedometer shows an increase of 5 km./hr. every 5 seconds	(b) is the pull of earth on the body
(c) Mass and weight	(c) cars, electric motors and cycles.
(d) Ball bearings and Roller bearings are used in	(d) it would be in uniform motion.
(e) gravity.	(e) is a unit which represents a measure of speed.

17. Arrange the following substances in order of their densities, starting from the highest value :

Copper, glass, water, milk, ice, alcohal, lead, cork, gold, common salt.

18. Fill in the blanks :

(i) Thrust is..................

(ii) A..................liquid offers greater buoyancy than a..................one.

(iii) All bodies appear..................when they are immersed in a liquid.

(iv) Liquids and gases exert pressure in..................

(v) ....is equal to the force acting on unit area.

(vi) The..................of water in the sea helps whales to move easily.

2

HEAT AND ITS EFFECTS

2.1. Heat and Internal Energy

When we stand in the sun or sit near a fire, we feel hot and when we touch a lump of ice we feel cold. Let us briefly examine the process of heating a kettle containing cold water. When the kettle is placed in contact with fire, the water becomes warmer. The condition of water has changed. Thus we say that the *thermal* condition of the water has changed and this change has taken place, because *something* has entered the water from the fire. The 'something' is known as **heat**. Heat always flows from a hotter body to a colder body under suitable conditions.

Experiments have shown conclusively that *heat is a form of energy* and all types of energy can be changed into heat energy. For example when we rub our hands, they become warm. The hammer for breaking stones becomes warm during action. Heat is the *internal energy* which an object possesses because its molecules are in motion and possess kinetic energy. The energy that turns the wheels of the steam engine comes from the steam. Wood and coal are used to boil water to produce steam. The coal or wood supply energy in the form of *heat energy* that makes the train move. Scooters, cars and trucks etc., are driven by the burning of petrol and diesel oil.

Man is dependent on heat. The most important source of heat is the Sun. Without the Sun, the trees and the animals would not be able to grow.

Due to this motion, each molecule possesses kinetic energy. When a substance absorbs heat, it causes two changes in matter. It increases the potential energy of matter by increasing the distance between the molecules and it increases the kinetic energy of matter by increasing the velocity with which the molecules are moving.

All the molecules of a substance do not absorb the same amount of energy, hence the resulting velocities of the molecules may differ greatly.

Most substances expand when heated. The average distance between the molecules increases causing expansion. The expansion is not due to an increase in the size of the atoms or molecules but due to increase in the space between the molecules.

2.2. Sources of Heat Energy

Our main source of heat is the

Sun. The Sun is about $1{\cdot}4 \times 10^6$ km. in diameter and about 150×10^6 km. away from us. The outside of the Sun is at a temperature of about 6,000°C and the temperature inside the Sun is estimated to be about 20,000,000°C. The radiant energy from the Sun warms the atmosphere and heats the Earth's surface to keep our planet at a temperature that can support life. Without the Sun, the Earth would have been a frozen, lifeless ball of rock and ice spinning through dark space.

We need fuel to furnish energy for our bodies, just as an engine needs fuel to run. The fuel furnishing this energy is the food we eat. Green plants act as food factories, taking in water and mineral from the air and combining these into food materials by using the heat energy from the Sun. Thus, the energy gets stored in the form of food by chemical change.

Energy from the Sun has always been used by green plants to form leaves, stems and roots. When ancient plants died, many of them fell into water and turned to layers of decaying materials. Over many years, heat and pressure gradually changed this material into various kinds of coal, gas or oil.

When these fuels burn in engines or furnaces, they release the energy which came from the Sun millions of years ago.

Mechanical energy can also be changed into heat energy. Rub your palms together for some time. The palms become hot. The friction involved in the rubbing, produces heat.

Turn a drill a little rapidly in a piece of hardwood, about 3 cm thick. The bit of the drill becomes hot due to friction.

Striking two objects together also produces heat. A nail when hammered into a block of wood becomes warm.

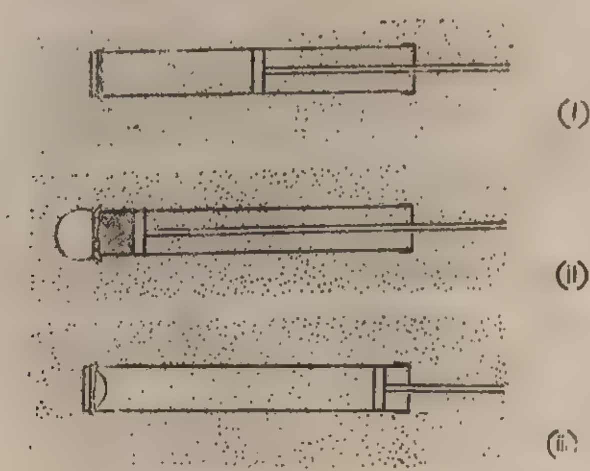


Fig. 2.1. Pressure of a gas changes due to change in its volume.

Another example of changing mechanical energy into heat energy is through the compression of a gas. Every gas is composed of molecules moving freely in all directions.

If an airtight piston is moved down in a cylinder, the air is pushed together or compressed into a smaller space. According to the kinetic molecular theory, the number of collisions between the molecules of one gas increases and the temperature of the gas and its container increases.

The molecules of the gas are pushed closer together when an air-tight piston moves down the cylinder.

Electrical energy can also be converted into heat energy.

Electric iron, toasters, dryers, bathroom heaters and soldering irons are a few examples of change of electrical energy into heat energy.

Connect a piece of nichrome wire, which can be obtained from an old toaster or an electric heater, across the terminals of a new dry cell for about one minute. You would find that the wire becomes hot.

Activity 2.1. Demonstration :

Take a fresh dry cell. Take a piece of iron wire about 50 cms long. Fix one end of it to one terminal of the cell.

Use pliers to stretch the other end of the wire so that it touches the other terminal as shown in the figure.

What happens to the wire? Be careful not to burn your fingers. You would observe that the wire becomes hot.

2.3. Thermal Expansion

In summer, telephone wires sag. During winter, they are stretched tight. Heat makes them expand. You must have noticed that roads and

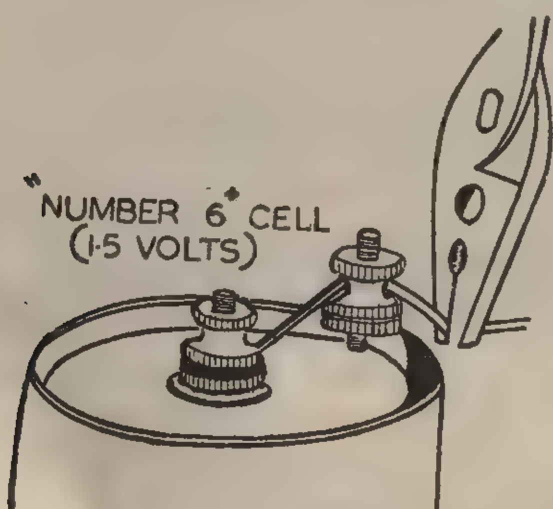


Fig. 2.2. Production of heat from electricity.

sidewalks often have joints filled with tar. The tar permits the slabs ot concrete to expand due to the heat from the Sun.

Scientists believe that expansion is caused by the action of molecules. They believe that all matter is made of molecules that are constantly in motion. Heat energy is the energy of vibrating molecules. As an object absorbs more heat, its molecules vibrate with increased energy. They require more space to vibrate and so the object expands.

Solids, liquids and gases all expand when heated. A substance in a gaseous state expands most. Liquids expand less than gases but more than solids.

Expansion of Solids

The expansion of different solids is not the same. Some solids expand more than the others. Brass expands more than iron. Zinc also expands more than iron but less than brass.

A solid may expand in length or in area or in volumes.

Activity 2.2.

Let us observe the expansion of a solid in the form of a tube.

Obtain a piece of straight, hollow glass tube about 3 mm in diameter and about 50 cms long. To raise the temperature uniformly for the entire length of the tube, force steam through it as shown in the figure.

The left end of the tube is fixed by a clamp so that it cannot move when the tube expands. Let the right end rest on a large darning needle. A pointer passing through the eye acts as an indicator. When the steam

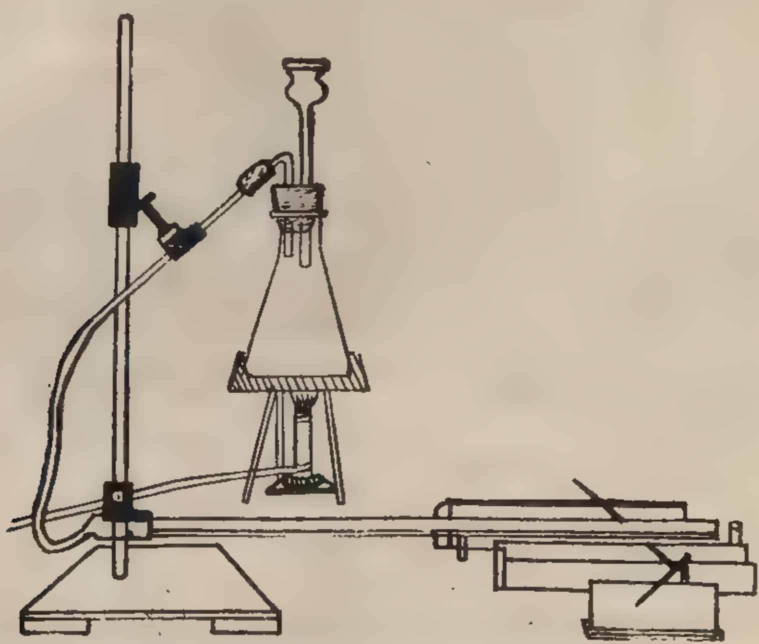


Fig. 2.3. Expansion of glass tube due to heat

passes through the tube, it expands and falls over the needle which causes the pointer to deflect. Thus the movement of the pointer clearly shows that the tube expands on heating.

Now stop the flow of steam. The glass tube begins to contract and gradually the pointer returns to its original position.

Activity 2.3

Take a metal ball which will just slip through a metal ring when both are at room temperature. Now heat the ball on a gas flame or on a spirit lamp and then place it on the ring. You will notice that the ball does not pass through the ring. This is because the volume of the ball has increased due to expansion. After some time, when the ball cools down, it passes through the ring again.

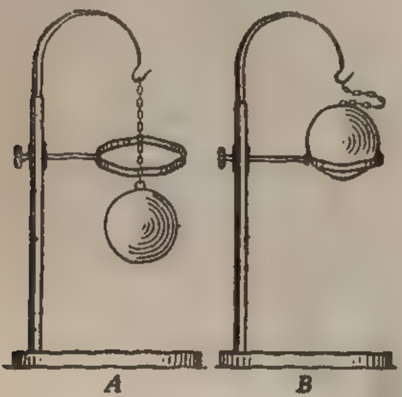


Fig. 2.4.

Activity 2.4

Take a bi-metallic strip consisting of long, narrow iron and brass strips riveted together. Heat this compound bar. It curves towards iron. This means that brass expands more than iron. Similarly it contracts more than iron, on cooling.

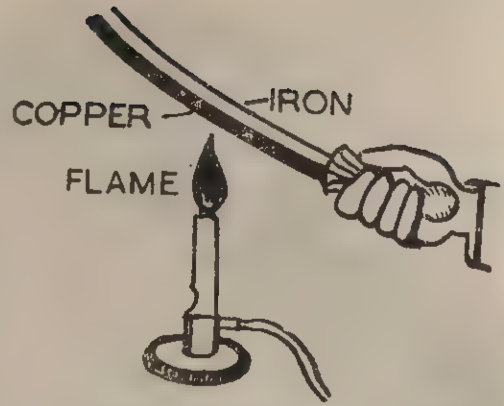


Fig. 2.5. Bending of a bimetallic strip

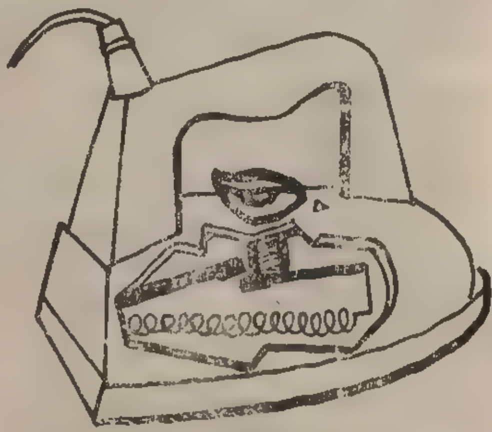


Fig. 2.6. Thermostat fitted in an electric press

Bi-metallic strip is used to control temperature and such a device is known as a thermostat. Thermostats are used in fire alarms, refrigerators, automatic electric presses, etc.

The diagram shows a themostat fitted in an electric press. When the temperature rises the strip bends upwards and breaks the circuit. When it cools down the circuit is again

completed. The gap-width is controlled by a knob on the top of the press. The size of this gap governs the length of time the iron is off and hence the average temperature of the press.

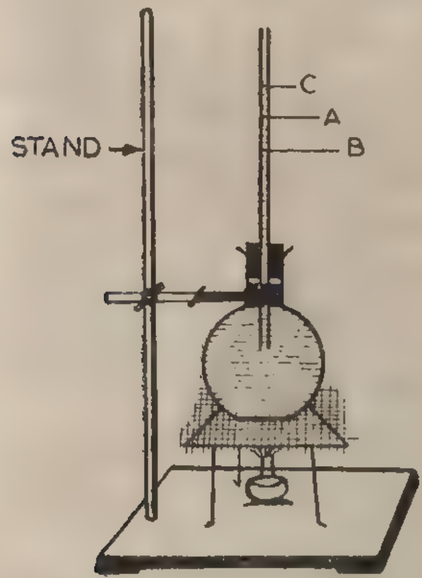


Fig. 2.7. Liquids expand when heated

Expansion of Liquids

Activity 2.5.

Obtain a spherical or conical flask, a piece of glass tubing about 50 cms long. Fill the flask completely with water coloured with ink or any food colouring, so that it can easily be seen. Put the glass tubing through the stopper and insert the stopper firmly into the neck of the flask as shown in Fig. 2.8.

When you do this, some of the liquid will be forced into the tubing. Warm the bottle by holding it in your hands or by heating it gently over a burner.

Watch the level of water in the tube. The level appears to fall in the beginning. Then it goes on rising steadily. The fall in the level is due to the expansion of the vessel which is heated first.

It is due to this reason that kettles and saucepans are not filled upto the brim, lest they should overflow on heating.

Considerable space is left in medicine bottles keeping allowance for the liquid contents to expand when they are sent from cold to hot countries.

Activity 2.6.

Expansion is different for different liquids.

Take three flasks, each fitted with a cork having a long tube. Fill each of them with a different liquid. Keep all the flasks in the same water bath and heat it.

Now watch the level of the liquids.

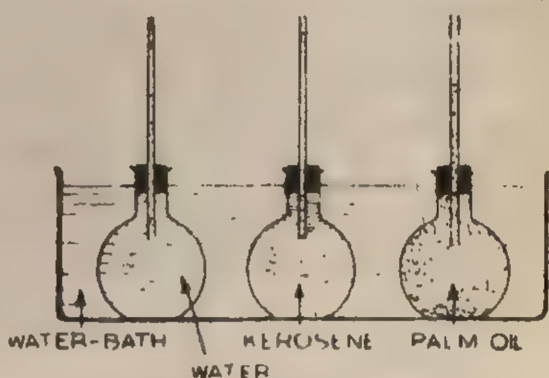


Fig. 2.8. Expansion of liquids is not the same.

You will find that the liquids do not rise to the same level. Each liquid expands but the expansion is different in different liquids.

Strange behaviour of water

All liquids expand on heating. But water behaves strangely. It contracts when heated between 0°C to 4°C. When the temperature rises above 4°C, the volume of water increases with the temperature. It is observed that the density of water is maximum at 4°C.

This strange behaviour of water is so important in the economy of nature that without it, probably all the aquatic animals and plants would have died.

During winter, the topmost layers of ponds and lakes are the first to cool. Hence, becoming denser, they sink and warmer water from below comes up. This in turn also gets cooled and sinks. This process continues until the whole of the water in the pond or lake is at 4°C.

On further cooling, the topmost layer expands and being less dense, remains floating on the surface. Gradually, the temperature falls to 0°C and then it freezes into a layer of ice. Ice is also lighter than water. Hence it remains floating. Ice is a non-conductor, therefore the water below does not freeze and there is always sufficient water at the bottom of a deep pond or lake to keep the aquatic animals alive.

Expansion of Gases

In fact, gases expand most readily. The expansion of gases is so large that the expansion of the containing vessel can be neglected in their case. All the gases, unlike solids and liquids, expand at the same rate.

Activity 2.7.

Take a flask. Fit a cork carrying a glass tube in it. Insert a drop of coloured water in the tube to act as an indicator.

Warm the flask. The indicator is pushed up due to the expansion of air.

2.4. Concept of Temperature and its measurement

In our daily life we frequently use the words 'hot', 'warm', 'cold', etc. When we stand in the sun for some time, we feel warm whereas in a shade we may feel cool. We often take 'a glass of cold water or 'a glass of

Fig. 2.9. Distribution of temperature in a frozen lake

hot milk'. Thus, the feeling of cold or hot on touching an object tells us about its thermal state in comparison to our body. *This quality by which we compare the hotness or coldness of bodies is called temperature.*

An object consists of many particles which may be moving at different rates from moment to moment. The temperature of an object depends upon the average kinetic energy of all its particles. If an object is hot, its particles have a high average kinetic energy and are in rapid movement.

The device used for measuring temperature is called *thermometer.* The expansion and contraction of certain liquids with change in thermal energy have been made use of in making a thermometer. Alcohol or mercury is generally used in making a thermometer. Alcohol has a very low freezing point, while mercury has a high boiling point.

A mercury thermometer is used in temperate and tropical climates and an alcohol thermometer is suitable in extremely cold climates.

2.5. Mercury Thermometer

The following table gives the normal freezing and boiling points of some of the liquids (under standard conditions).

Liquid	Freezing Point in °C	Boiling Point in °C
Water	0	100
Mercury	−39	357
Alcohol	−130	78

Mercury has a wide range of temperatures between its freezing and boiling points. Apart from this it has several other properties which makes it suitable as a thermometric liquid.

These properties are :

(*i*) It is a shining, silvery white liquids which can be seen very easily from outside the glass tube.

(*ii*) It does not stick to the glass.

(*iii*) Its expansion is fairly uniform over a very wide range of temperatures.

Mercury thermometer is the instrument most commonly used for measuring temperature. It consists of glass bulb, generally cylindrical or spherical provided with a stem of capillary bore (Fig. 2.10). The bulb and part of the stem are filled with mercury. As mercury is much more expansible than glass, the level of mercury rises up as the instrument is heated. The instrument is graduated with a suitable scale in order to obtain

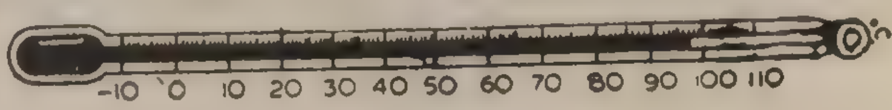


Fig. 2.10. Mercury Thermometer

a numerical measure of temperature.

To construct a mercury thermometer four operations are necessary namely (*i*) selection and preparation of the capillary tube, (*ii*) introducing mercury, (*iii*) determining the fixed points and (*iv*) graduating the thermometer.

(*i*) *Selection and Preparation of the Capillary Tube* :

First of all a piece of thick walled glass capillary tube is selected. It is thoroughly cleaned and then dried by flowing a current of hot air in it. After that it is tested for the uniformity of the bore. For this purpose a short thread of mercury about 2·5 cm in length is sucked up into the tube. This thread is moved along the tube and its length is measured at various positions. If the thread has the same length throughout the tube, the bore is uniform.

When a suitable tube is obtained, one of its ends is heated and melted and is then blown into a bulb of a suitable size.

(*ii*) *Introducing Mercury* :

For introducing mercury into the bulb, a funnel is attached to the bulb by means of an India-rubber joint (Fig. 2.11). Sufficient clean dry mercury is poured into the funnel. The bulb is then heated and cooled. On heating the air in the bulb expands and rushes out of the funnel and on cooling the air contracts and a small quantity of mercury enters the bulb. This process of alternate heating and

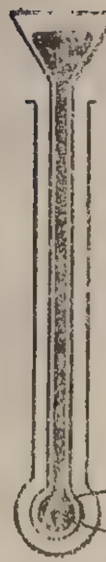


Fig. 2.11. Introducing mercury

cooling is repeated several times until the bulb and a part of the stem are full of mercury. The bulb is then heated continuously and mercury in it is boiled so that the mercury vapours push out traces of air and moisture. The bulb is then allowed to cool and mercury forms a continuous column filling the bulb, tube and part of the reservoir. While still warm the excess of mercury in the reservoir is poured off. The mercury now fills the bulb and the stem and while it does so the top end of the tube is sealed. The thermometer is now ready for graduation.

(*iii*) *Determining the Fixed Points* :

For graduating a thermometer first of all two marks are made on the stem, the first corresponding to the freezing point of water or ice point and the second corresponding to the

boiling point of water or steam point. These marks are known as *fixed points* because the temperatures to which they correspond are constant.

(*a*) **Freezing Point** : For determining the freezing point, the thermometer tube is placed vertically in a funnel (Fig. 2.12) containing small

Fig. 2.12. Fixing of lower point

pieces of ice so that the bulb and a part of the stem are completely surrounded by melting ice. When the level of mercury becomes perfectly stationary, a mark is made on the stem at the extreme end of the mercury column. This gives us the lower fixed point.

(*b*) **Boiling Point** : Take a flask containing water and hold it above the flame as shown in Fig. 2.12. When the water boils in the flask, the steam circulates in the flask and finally escapes. Suspend the bulb of the thermometer in the flask containing boiling water such that the bulb remains above the level of water. After sometime the mercury level in the stem becomes constant. When it becomes stationary, the level in the tube is marked 100°C. Temperature corresponding to 100°C is called *upper fixed point* or *boiling point* or *steam point*.

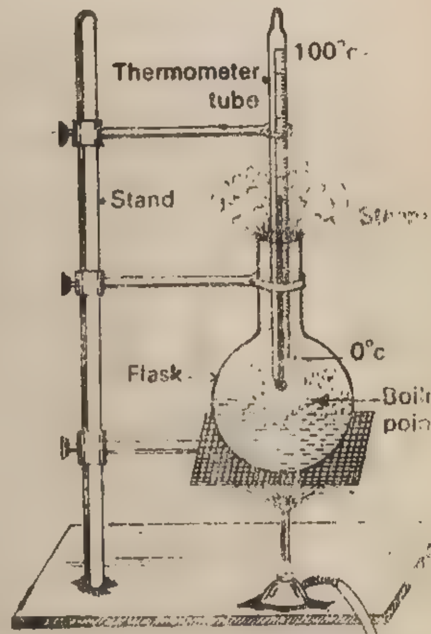


Fig. 2.13.

(*c*) **Graduating the Thermometer** : After marking the fixed points on the stem, the distance between these two points is divided into a suitable number of equal divisions called *degrees*.

Temperature Scales

The space between the two fixed temperatures when divided into a suitable number of equal divisions constitutes a *scale* (Fig. 2.13). There are four scales now in use, namely (*i*) Celsius or Centigrade scale, (*ii*) Reaumur scale, (*iii*) Fahrenheit scale, and (*iv*) Absolute or Kelvin scale.

(*i*) *Celsius Scale* : This scale was

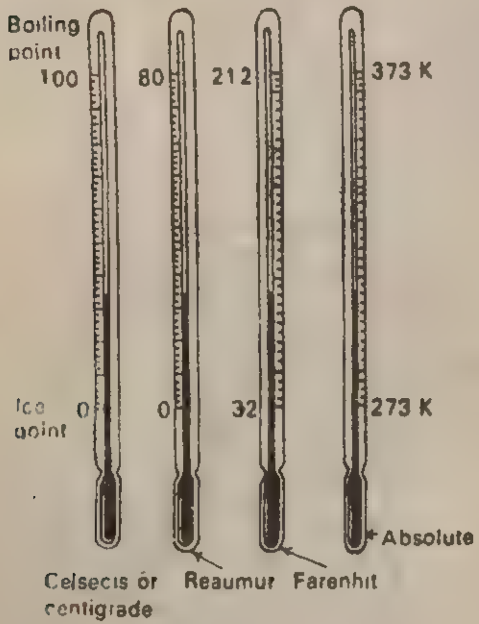


Fig. 2.14.

introduced by Celsius, a Swede. On this scale the freezing point or ice point is taken as zero and marked 0°C and the boiling point is marked 10°C. The distance between these two points is divided into 100 degrees. The divisions below zero are marked *negative*. Thus −5°C indicates a temperature 5°C below 0°C.

(*ii*) *Reaumur Scale* : This scale was invented by French scientist named Reaumur. On this scale, the freezing point is marked 0°R and the boiling point 80°R.

(*iii*) *Fahrenheit Scale* : On this scale the lower fixed point or ice point is marked 32°F and the upper fixed point is marked 212°F. The interval between them is divided into 180 equal degrees.

(*iv*) *Absolute or Kelvin Scale* : This is the same as Celsius scale with the difference that its zero is at −273°C. Thus 0°C corresponds to 273 K. The upper fixed point is 373 K. The interval between the ice point and the upper fixed point or boiling point is divided into 100 equal degrees. Zero degree Kelvin (0K) is −273°C which is the lowest temperature that can ever be achieved.

Mercury freezes at −39°C and boils at 357°C. Hence a mercury thermometer cannot be used to measure temperatures below −39°C and above 357°C. Alcohol freezes at −130°C and boils at 78°C. Hence an alcohol thermometer is used to measures very low temperatures.

2.6. Clinical or Doctor's Thermometer

This is a special type of thermometer used by doctors to read the temperature of the human body. It was invented by Sir Clifford Allabutt in 1870. It is very sensitive and quick acting.

The capillary tube has got a constriction just above the bulb. The stem is short and graduated from 95°F to 110°F or 35°C to 44°C. This is because the normal temperature of the human body is about 37°C or

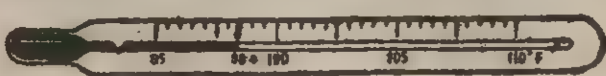


Fig. 2.15. Doctor's thermometer

98·4°F. Each degree is generally divided into five equal parts so the fraction of a degree can be read (Fig. 2.15). To make it sensitive, the capillary tube is made very fine. The bulb is made thin and long to make the thermometer quick-acting. The constriction does not allow the mercury column to fall after it is taken out from the body whose temperature is measured. We have to shake it before using it again.

It has been designed in such a way that the mercury column appears magnified when seen from the front. This helps quick and accurate reading of the temperature.

2.7. Measurement of Heat

The unit of heat is *calorie.* Since water is such a common substance it is convenient to define the unit of heat by observing the effect that is produced by adding or taking away thermal energy from water.

The calorie (cal) is defined as the quantity of thermal energy required to raise the temperature of 1 gram of water through 1°C.

Kilocalorie (*Kcal*) is taken as another unit of heat which is equal to 1,000 calories or the quantity of heat required to raise the temperature of 1 Kg. of water through 1°C.

2.8. Specific Heat

If we take one gram of pure water and raise its temperature by 1°C, we have to give 1 calorie of heat to this water. Similarly if we take one gram of copper and raise its temperature by 1°C we have to give 0·095 calorie of heat to it. Thus every substance of equal mass needs different amount of heat for the same rise of temperature. In other words some substances become warmer than other substances when the same amount of heat is supplied to them. This is because of the property of sepecific heat.

The quantity of heat which is needed to raise the temperature of one gram of a substance by 1°C is known as the **specific heat** *of the substance.* It is denoted by 'S'. Its unit is *calories per gram per degree centigrade.* In the SI system, the unit of specific heat is *kilocalorie per kilogram per degree centigrade.*

The numerical value of specific heat of some substances is given below :

Water	1·00
Lead	0·03
Copper	0·09
Iron	0·11
Aluminium	0·21
Kerosene oil	0·51
Ice	0·55

The quantity of heat (Q) gained or lost by a body is proportional to its mass (M) the specific heat (S) and the rise in temperature (T) of the body.

$$\boxed{Q = M \times S \times T}$$

Activity 2.8.

Take two pieces of any metal of unequal mass. Place both of them in boiling water.

Now take two beakers of equal capacity and fill equal quantity of water at room temperature.

Transfer the metal pieces, one each in one beaker and observe the change in temperature.

You will notice that the rise in temperature is more in the beaker in which the bigger piece of metal was transferred. In the case of transfer of heat from one body to another, the heat lost by the hot body is equal to the heat gained by the cold body, but the total of the internal energy of both the bodies taken together before and after the transfer of heat, remains the same.

Hence we state that in case of thermal equilibrium between two bodies :

$$\boxed{\text{Heat gained} = \text{Heat lost}}$$

2.9. The Heat of Combustion

We burn wood, coal, kerosene, oil or gas for producing heat for domestic or industrial purposes. So it is necessary to know how much quantity of heat is produced when a definite quantity of fuel is burnt.

The quantity of heat obtained when 1 Kg. of fuel is burnt completely, is called its heat of combustion or the calorific value of fuel.

This quantity is found to be different for different fuel. Heat of combustion of some fuels $\frac{\text{(in Kcal)}}{\text{Kg}}$ is given below :

Fire wood	3000
Coal	7000
Gas	8500
Diesel Oil	10,500
Petrol	11,000
Kerosene	11,000

The calorific value of the fuel is of very great importance to big industrial establishments.

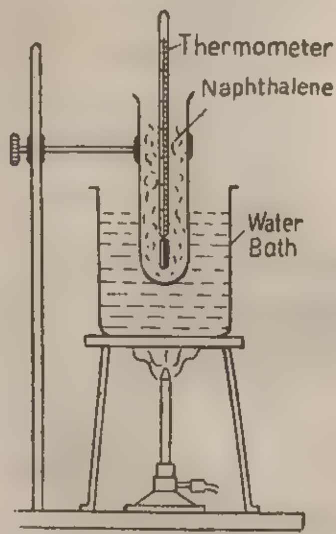


Fig. 2.16. Melting point of naphthalene

In Biology, too, energy is supplied to the body from food which is slowly oxidised or burned in the process of digestion. Thus, the knowledge of calorific value of various food is of utmost importance for the selection of correct diet.

2.10. Melting and Crystallization

The process by which a substance changes from the crystalline state to the liquid state is called melting.

The process by which a substance changes from the liquid state to the

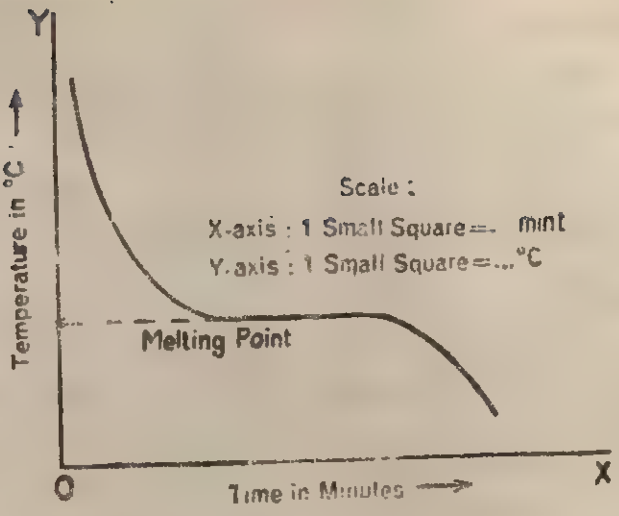


Fig. 2.17

solid state is called crystallization.

Activity 2.9.

In order to determine the melting point of naphthalene, put the test tube containing the naphthalene and the thermometer into a beaker half-filled with water and heat it over a spirit lamp.

When the temperature of the naphthalene has reached 60°C, start noting the temperature after every minute till it reaches 90°C.

Remove the test tube from the hot water and let it cool. Note the temperature every minute till it drops to 60°C again.

Draw a graph of the temperature against time.

From the graph, it will be observed that the temperature remains constant during the process of melting and also during the process of crystallization.

The melting points of different substances are different. During the process of melting, its internal energy increases and its particles vibrate faster. At the melting point the speed of the particles is so much increased that their regular arrangements is disturbed and consequently the solid turns into liquid.

2.11. Changes of volume on melting :

You must have heard about the bursting of water pipes in hills during extreme cold. When the water freezes into ice, it expands. The force of expansion is so great that the pipes sometimes burst.

Most of the solids expand on melting and contract on freezing.

2.12. Heat of Fusion (*Latent Heat*) :

Take a few pieces of ice in a beaker. Heat it gently and note the temperature of the ice. You will see that although the ice is being heated,

the temperature of the ice does not increase till all the ice has melted.

No increase in temperature means that there is no increase in the kinetic energy of the molecules of the body. So, the quantity of heat, supplied during the process of melting, is utilized in increasing the potential energy of the molecules of the body. Thus, we see that in melting, the breaking up of the orderly arrangement of particles is accompanied with the increase in their potential energy.

The quantity of heat required to melt 1 kg. of a substance at its melting point is called its heat of fusion or *Latent heat of fusion.*

The Latent heat of fusion of some substances in Cal/g. or Kcal/kg is given below :

Ice	80
Naphthalene	36
Copper	42
Iron	6·6
Lead	5·9

2.13. Freezing Mixtures :

We use freezing mixture in the freezer for making ice cream. It is a mixture of salt and ice. We cannot freeze the ice cream by using ice alone, because ice cream freezes at a temperature below 0°C.

If salt is added to ice, normally the temperature falls to about 10°C to −21°C depending upon the ratio of salt and ice.

By using a mixture of ice and potassium nitrate, temperatures as low as −55°C can be obtained.

2.14. Vaporization :

When a liquid changes to the gaseous state, the process is known as vaporization.

If the vapours of a liquid are cooled, they condense into liquid state. The change of state from a gas to a liquid is called *condensation.*

Evaporation and boiling are both examples of vaporization.

Evaporation :

Wet clothes dry sooner on some days than on others. It is because the rate of evaporation is not the same always. It depends on the following factors :

(*i*) **The nature of liquid :**

Different liquids evaporate at different rates. Spirit or alcohol evaporate faster than water.

(*ii*) **The temperature of liquid :**

Evaporation goes on at all temperatures but if the liquid is at a higher temperature, it is quicker. With increase in temperature, the average kinetic energy of the molecules increases. So a greater number of molecules possess sufficient kinetic energy to escape from the liquid.

(*iii*) **The area of the liquid surface :**

Rate of evaporation increases with the increase in area of the exposed liquid surface.

(*iv*) **The movement of air :**

On a still day it takes longer to dry the clothes but when the wind is blowing, the clothes dry very soon.

(v) Dryness of air :

If the air is dry, *i.e.*, contains less amount of water vapour, evaporation takes place quickly. If the air contains more water vapour (as in rainy season), evaporation becomes slow.

In the process of evaporation, the molecules with great kinetic energy escape from the liquid. Consequently the remaining molecules in the liquid possess less average kinetic energy. This decrease in average kinetic energy results in the fall in temperature during evaporation.

Water kept in an earthern pitcher becomes cool due to the evaporation of water through the pores in wall of the pitcher.

Boiling :

Set up the apparatus as shown in Fig. 2.18.

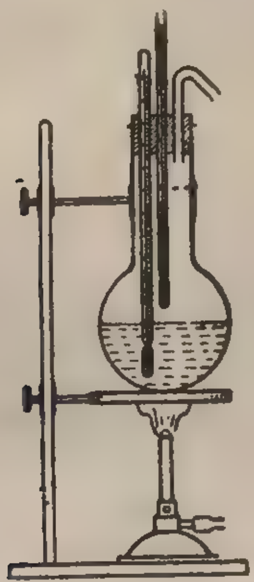


Fig. 2.18. Determination of boiling of liquid.

It consists of a round bottomed flask fitted with a side tube and a thermometer so fitted that its bulb is well above the liquid.

Liquid is heated. (Inflammable liquids like alcohol, spirit etc., are heated on a sand bath and not directly upon the flame). The temperature goes on increasing till the liquid begins to boil. As soon as the liquid begins to boil the temperature stops rising. This stationary temperature gives the boiling point of the liquid.

The main difference between evaporation and boiling are :

1. Evaporation takes place from the surface of the liquid, whereas boiling is due to vapour formation inside the whole liquid.

2. Evaporation takes place at all temperatures whereas boiling takes place at a fixed temperature under a definite pressure.

3. Evaporation is a slow process whereas boiling is a quick process.

The quantity of heat required to convert 1 kg. of a liquid into vapour at its boiling point is called the *heat of vaporisation* of the liquid.

Heat of vaporization measures the increase in the internal potential energy of 1 kg. of a liquid when it is converted into its vapour at constant temperature.

1 kg. of water requires 540 Kcal. of heat to change into steam at 100°C. Thus the internal energy of 1 kg. of steam at 100°C is 540 Kcal more than the internal energy of 1 kg. of water at the same temperature.

2.15. Food Preservation :

Food, kept in warm, moist places gets spoiled very soon due to the action of some bacteria. Spoilage of food can be prevented by heating so that the spores of bacteria get killed and these heated products are then placed in sealed tins.

Food products can also be prevented from decay by freezing or by adding excess of sugar or salt. Under high concentration of salt of sugar, the bacteria cell cannot live and hence cannot grow.

2.16. Cooking of Food

The term of cooking is usually applied to the treatment of food by heat which may be used in one of the three forms :

Dry heat—as in roasting, grilling and baking. Dry heat includes heat from electricity, gas, coal, coke or wood.

Moist heat—as in steaming, boiling and stewing. Moist heat involves the use of water, milk vinegar or any other liquid.

Hot rat—as in frying. A variety of animal and vegetable oils and fats may be used for this purpose.

Advantages of cooking :

1. It makes food tasty, prevents monotony and gives variety.

2. It is necessary, with many foods, to make them digestible. Thus, starch is indigestible until the starch grains burst by heat, and when meat is cooked, the fat is melted, the connective tissues are gelatinised and the muscle fibres are prepared for digestion.

3. Heat kills harmful bacteria and parasites.

4. Cooked food can be preserved for a longer time than raw food.

SUMMARY

1. Heat is the energy which an object possesses because its molecules are in motion. Heat possessed by a body is the average kinetic energy of all the separate particles.

2. Our main source of heat is the Sun. Coal, gas, oil are other sources of heat.

3. Mechanical energy can be changed into heat energy. Electrical energy can also be converted into heat energy. Atomic or nuclear energy can also be converted into heat energy.

4. Solids, liquids and gases all expand when heated. A substance in a gaseous state expands most. Liquids expand less than gases but more than solids.

5. Water when heated behaves strangely. It contracts when heated between 0°C to 4°C. When the temperature rises above 4°C, the volume of water increases with the temperature. The density of water is maximum at 4°C.

6. Degree of hotness or coldness in a body is called temperature. The device used for measuring temperature is called thermometer.

7. The unit of heat (thermal energy) is kilo *Calorie*. It is the quantity of heat required to raise the temperature of 1 kg. of water through 1°C.

It is also measured in *Joules.*

8. *Specific heat* is the quantity of heat required to raise the temperature of unit mass of a substance through 1°C. It is measured in Joule per Kg. per degree C.

9. The process by which a substance changes from the crystalline state to the liquid state is called melting and the temperature at which it takes place is called its melting point.

10. The quantity of heat required to melt 1 Kg of a substance at its melting point is called its latent heat of fusion. It is measured in Kilocalorie per kg.

11. When a liquid changes to the gaseous state, the process is known as *Vaporization.* The temperature at which it takes place is called its boiling point.

QUESTIONS

1. What effect does the absorption of heat has on the molecules of a substance ?

2. What evidence have you found that heat is a form of energy ?

3. What kinds of energy can be converted into heat energy ?

4. Why are lumps of ice more ettective in cooling a drink than iced water ?

5. If ice is kept in a place where the surrounding temperature is 0°C, do you think that ice will melt ?

6. Describe the changes which occur in a substance when its molecules gain in Kinetic Energy.

7. Explain why the heat, supplied to a substance during melting does not produce any change in its temperature ?

8. Calculate the quantity of heat, required to melt 5 kg. of ice taken at 0°C.

9. Why do we sweat more during the rainy season ?

10. Explain why a perspiring person feels more comfortable after sitting under a fan ?

11. Calculate the heat required to turn 80 g. of water at 100°C completely into steam at the same temperature.

12. Explain why food can be preserved by keeping it in an ice box or a refrigerator.

13. Discuss the advantages of cooking food.

14. Why does a bicycle tube have more punctures in summer than in winter ?

15. Why does a stone become hotter than clay on a hot summer day ?

16. How does the process of pasteurization—heating the milk and then quickly cooling it down—help to preserve the milk for the longer time ?

17. When a worker breaks stones with his hammer, why does the temperature of the hammer increase ?

18. Calculate the heat required to heat 100 g. of copper from 20°C to 30°C. Sp. heat of copper=0·09.

19. Match the words given in column A with those of column B and write the complete sentences :

Column A	*Column B*
(*a*) Water boils at	(*a*) 0°C or 32°F
(*b*) Melting point of ice is	(*b*) 540 Kcal/kg
(*c*) Latent heat of ice is	(*c*) 80 Kcal/kg
(*d*) Latent heat of water is	(*d*) 350°C
(*e*) Mercury boils at	(*e*) 100°C or 212°F
(*f*) Alcohol boils at	(*f*) 78°C.

20. Complete the following statements by filling the blanks with suitable words :

(*i*) Heat always flows from a body at a..................to a body at a ....

(*ii*) Mercury solidifies at..................whereas alcohol solidifies at ....

(*iii*) Heat causes many..................changes.

(*iv*) Heat is capable of doing work as in..................

(*v*) $-10°C$ indicates a temperature..................below..................

(*vi*) Whenever a substance undergoes a change of state it does so at a..................temperature.

(*vii*) A thermometer measures.................. ; it does not measure ....

3

TRANSFER OF HEAT

3.1.

When we warm ourselves before a fire or when the hot milk makes the glass too hot to hold in the hand, the heat moves from one place to another. The transfer of internal energy from a body at higher temperature to a body at lower temperature without mechanical work being done, is called transfer of heat. The amount of internal energy transferred in the process is known as the quantity of heat. Heat continues to be transferred as long as there is difference in the temperatures of two bodies or between the different parts of the same body. When their temperatures become equal, the condition of thermal equilibrium is reached and the transfer of heat decreases.

There are three distinct processes by which the transfer of heat may take place—conduction, convection and radiation.

3.2. Conduction

Conduction is the type of heat transfer in which the kinetic energy of molecules is given directly by contact to other molecules with which they collide.

Heat travels in solids by the process of conduction, but the rate at which heat travels in different solids is not the same. Some solids are better conductors of heat than others.

Activity 3.1.

Fix some small iron nails on the copper rod with the help of molten wax and clamp the rod to a stand as shown in Fig. 3.1.

When the copper rod is heated over a spirit lamp at one end, the iron nails drop one by one, starting from the hot end. It shows that heat is transferred slowly from one end to the other end of the rod.

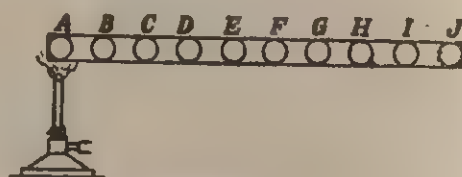


Fig. 3.1. Transfer of heat through a copper rod

At the heated, end, the molecules vibrate faster than the neighbouring molecules. As these faster molecules strike their neighbours, the latter also begin to vibrate faster. This process continues along the rod and so the heat is transferred from one point to another.

Good Conductors

Activity 3.2.

To compare the conduction of heat in different metals, for example, copper and iron, take two similar rods, one made of copper and the other made of iron. Fix the rods, as shown in Fig. 3.2.

The junction of the rod is heated by a spirit lamp. The nails start falling from the copper rod sooner than the iron rod. So the experiment shows that copper is a better conductor of heat than iron.

All metals, specially gold, silver and copper are *good conductors of heat* while wood, leather, cork, etc., are *poor conductors of heat.*

Bad Conductors

Activity 3.3.

Take a test tube filled with water. Put some sugar crystals in it. Hold the tube in an inclined position. Heat the water at its upper part, to prevent convection. It will be observed that the water starts boiling there but the sugar crystals remain undissolved. This proves that water is a bad conductor of heat.

Activity 3.4.

To show that air is a bad conductor of heat, hold a test tube in an inclined position. Insert your finger into the mouth.

Fig. 3.2. Comparison of heat conduction through iron and copper

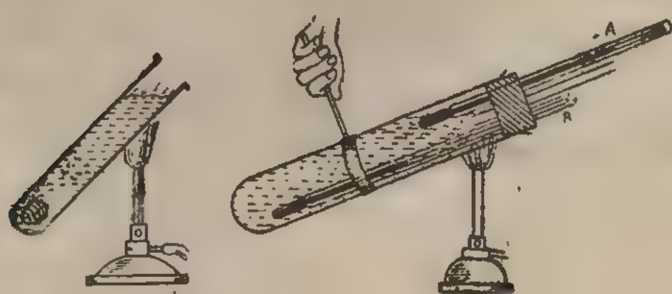


Fig. 3.3. Air is a poor conductor of heat

Applications of conduction in our daily life

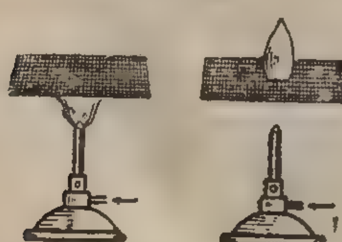
The knowledge of conductivity of the different materials has been extensively used in our daily life. All the cooking utensils are made of good conductors so that they may pass on the heat quickly to the food. The handles of metallic kettles, frying pans and pressing iron are all made of bad conductors to enable us to hold them even when they are hot. We use woollen clothes in winter to keep warm.

Davy's safety lamp is a very important application of good conductor which has brought about a revolution in the history of mining. The lamp has been invented by Sir Humphrey Davy and is known after his name.

The principle, on which, the lamp has been constructed is explained in the experiment given below :

Activity 3.5.

Hold a piece of copper wire gauze over a bunsen burner (Fig. 3.4). Turn the gas on and light the gas under the gauze. The flame will not pass above the gauze because the heat of the burning gas is quickly conducted away by the copper gauze ; hence the gas passing up does not remain hot enough to burn.



(i) Fig. 3.4. (ii)

Next time turn the gas on and light the gas above the gauze (Fig. 3.4. (*ii*) The flame will not pass below the gauze for the same reasons as given above.

Thus the copper gauze being a good conductor, it does not allow the flame to pass from one side to the other.

Construction of Davy's safety lamp

It is an ordinary oil lamp in which the glass chimney is replaced by a wire gauze chimney. In fact, the flame is surrounded by a cylinder of wire gauze on all sides. So, the heat of the flame in this lamp cannot set fire to explosive gases that are suddenly let off in mines and the miner can use it quite safely. All the more, the presence of such gases can be immediately known because the gas begins to burn inside the wire gauze. In such event the miners extinguish the lamp and come out of the mine.

The Davy's Safety Lamp has saved thousands of miners who used to perish in the explosions of the mines due to the inflammable gases catching fire.

The motor cycle engine has no water cooling system to cool it. But the engine must be cooled otherwise on being over-heated it will stop

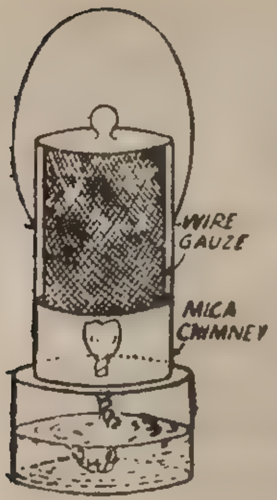


Fig. 3.5.

working. So it is provided with cooling fins. The fins provide a large surface and transmit the heat of the engine very quickly like the wire gauze. Thus the engine is prevented from being over heated.

The ice box, and hay box are other applications of conduction. Insulating material as cork, saw dust or felt is generally used in them to check the heat from flowing through them.

3.3. Convection

When we heat a fluid, the fluid molecules move farther apart, the density of the heated portion of fluid is less than the density of the unheated portion. The heated fluid, being lighter, rises and produces a convection current. When the heated molecules collide with other matter, they lose some of their kinetic energy to the other substance, thereby transferring heat. This type of heat transfer by fluid movement is called convection.

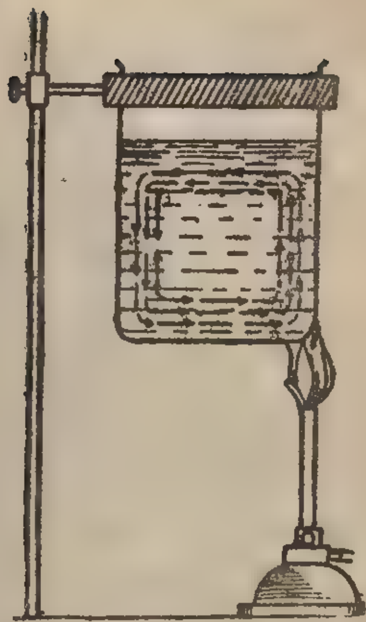


Fig. 3.6.

Conduction or convection cannot occur in vacuum because they require contact between molecules of matter.

Activity 3.6.

Take a glass beaker as shown in the Fig. 3.6. Fill it with water. Put some potassium permanganate crystals at the open end. Slowly heat one corner of the tube over a spirit lamp. Observe the direction of motion of the coloured water in it.

Activity 3.7.

Take a wooden box fitted with two glass chimneys on the top and provided with a sliding glass front.

Slide the glass front and put a burning candle under one of the chimneys and close the front again. After a few seconds, hold a smouldering piece of wood over the other

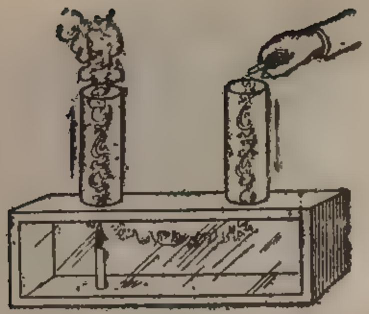


Fig. 3.7 Convection currents in air

chimney and note the movement of the smoke. The smoke enters from one chimney and goes out from the other under which the burning candle has been put.

The air above the candle gets heated and rises up. The cold air entering from the other chimney takes its place. Thus, the air currents are set in.

Convection currents in liquids and gases play an important part in nature and also in our daily life.

Ventilation in houses

We breathe in oxygen and breathe out carbon dioxide. The carbon dioxide being hot rises up and goes out of the room through the ventilators provided near the ceiling. The fresh air being heavy gets into the room through the doors and windows.

Land and sea breeze

The people living on the coast experience land and sea breezes daily. During the daytime, the land becomes hot quicker than the sea. This results in the air over the land to rise and the cool air from the sea to come in to take its place.

At night, the land cools faster than the sea. Hence, the sea being warmer than the land, the air above it rises and is replaced by the cool air from the land.

Ocean currents

It is observed that in oceans, hot water currents move from the equator towards the poles and cold water currents move from the poles towards the equator.

3.4. Radiation

On a cold night, when we sit in front of a fire we feel warm. Heat is transferred from fire to us without heating the air in between.

We feel the Sun's heat although the Sun is so far away and there is no air or any other medium for a large distance in between the Sun and ourselves.

From the above examples it is clear that there is another process by which heat can be transferred from higher to lower temperatures. This process is known as **radiation**.

Radiation is a process by which heat is transferred from one place to another without heating the intervening medium or in the absence of air or any other medium.

There is nothing between the sun and the earth to conduct heat or to allow convection currents to flow, yet, we are warmed by the sun's rays. It does so by radiation, that is, in the form of heat rays. The sun sends out

heat rays just like it sends out light rays. These rays are rather like light rays in the way they travel, but they do not enable us to see, like light rays do. When these heat rays fall on anything, they make that object hot.

Activity 3.8.

Take a piece of paper and a convex lens. Allow the sun's rays to pass through the convex lens and adjust the position of the paper, such that the smallest possible image of the sun is obtained on the paper. It will be observed that the paper start burning but if you touch the lens, it will be more or less at the same temperature as it was before.

Activity 3.9.

Take a glass flask and paint it black. Pass a glass tube bent at right angles through its cork. Introduce a small quantity of coloured liquid into the tube. It acts as an index of change of temperature inside the flask.

Take a room heater and keep it by the side of the black flask. The index moves forward. Change the distance between the flask and the room heater. The position of the index will also change.

Repeat the experiment, without painting the flask. Observe the difference between the two experiments.

You will notice that a smooth white surface is a *good reflector* of heat, while a rough black surface is a *good absorber of heat.*

Fig. 3.8. Expansion of air due to radiated heat

Heat radiations are found to possess the following properties :

(*i*) They travel with the same velocity as that of light, *i.e.*, 3,00,000 km per second.

(*ii*) They travel in a straight line.

(*iii*) They are reflected after striking a shining surface.

(*iv*) They can be refracted through transparent medium.

(*v*) They do not heat the intervening medium and can pass through a vacuum.

(*vi*) Intensity of heat radiations decreases with the increase in distance.

3.5. Thermos Flask

A thermos flask is an example of a useful device in which the normal conduction, convection and radiation of heat are greatly reduced.

The double-walled glass vessel,

silvered on the inside, helps to reduce heat exchange as follows :

Glass being a poor conductor, reduces heat exchange by conduction ; evacuating much of the air between the double walls reduces the loss by convection, and the silvering reflects radiated heat which tries to enter or leave the vessel.

The glass bottle is placed in a metal or plastic case. A rubber or plastic cork is used for closing the bottle.

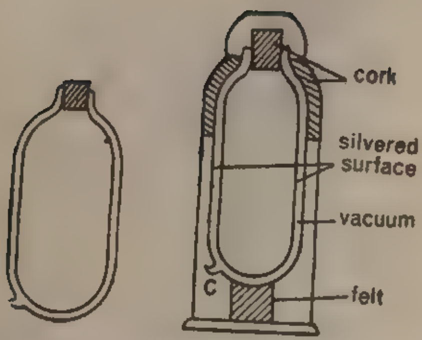


Fig. 3.9. Thermos Flask

SUMMARY

1. There are *three* distinct processes by which the transfer of heat may take place—*conduction*, *convection* and *radiation*.

2. Conduction is a process by which heat is transferred from one part of the body to the other part *without* actual movement of the particles of the body. The kinetic energy of the molecules is given directly by contact to other molecules with which they collide.

3. Some solids are better conductors of heat than others. Davy's Safety Lamp is a very important application of good conductor.

4. Convection is a process by which heat is transferred from one place to another by the actual movement of the particles. The process of convection is used to cool the engines of motor cars ; heating system in buildings ; ventilation in houses land and sea breeze ; ocean currents, etc.

5. Radiation is a process by which heat is transferred from one place to another without heating the intervening medium. We receive heat from the sun by radiation.

6. A thermos flask is an example of a useful device in which the normal conduction, convection and radiation of heat are greatly reduced.

QUESTIONS

1. Why is the handle of a kettle for boiling water usually covered with thin cane strips ?

2. How do woollen clothes keep us warm in winter ?

3. On a cold winter day, why do we feel colder when the sky is clear than when it is cloudy ?

4. How does a thermos flask help to keep a warm liquid warm, and a cold liquid cold ?

5. What causes the draught up a chimney ?

6. Explain why, in the electric kettle, the heating element is placed at the bottom and not at the top of the kettle ?

7. Usually ice is covered with saw dust. Explain the reason ?

8. Explain why people prefer using white or light coloured clothes in summer ?

9. At low temperatures, why do metallic objects, when touched appear to be colder than wooden objects ?

10. (*a*) Name the various modes of transference of heat,

(*b*) Distinguish between :

(*i*) Good and poor conductors,

(*ii*) Good and bad absorbers.

Give *three* examples of each in (*i*) and (*ii*).

11. Pick out the good and bad conductors of heat from the following list :

Brass, card board, ebonite, glass, iron, brick, straw, mercury. air, silver, copper, wood, leather, wool.

12. Rearrange the items of column B so that each one is on the same line with that in column A which is most closely related to it.

Column A	*Column B*
(*a*) Sun cooker	(*a*) keeps hot things hot and cold things cold.
(*b*) Black bodies	(*b*) are caused by convection.
(*c*) Trade winds	(*c*) receives heat by radiation.
(*d*) Thermos flask	(*d*) is based upon conduction of heat.
(*e*) Davy's safety lamp	(*e*) are good absorbers of heat.

13. Fill in the blanks with suitable words :

(*i*) Air is a very..................

(*ii*) All metals readily...............heat whereas gases and liquids are ....with the exception of...............which is a good conductor.

(*iii*) We get heat from the Sun by means of...............

(*iv*) In convection heat travels...............the movement of the particles.

(*v*) In conduction, heat travels...............the movement of the particles.

(*vi*) Air and water are heated by...............

4

LIGHT AND OPTICAL INSTRUMENTS

4.1.

In ancient times man depended on the light of the sun by day and the moon and the stars by night. It was a great step forward when the first caveman pulled a glowing stick from his fire and carried it to light his cave.

In a dark room you cannot see anything even though you keep your eyes open. As soon as you switch on a lamp, objects in the room become visible. Thus, you can see only in the presence of the light. Also, you cannot see with your eyes closed, even if the source of light is present. The eyes have the special property of sight.

For vision you need a source of light as well as your eyes.

4.2. Source of Light

Our chief source of light energy is the sun. It is believed that the energy of the sun is atomic energy. If it were not for the light we get from the sun, life on the earth would not be possible. Light enables a green plant to perform the miracle of photosynthesis, the amazing chemical change by which it combines carbon-dioxide water and sunlight into starch and oxygen.

A large number of artificial sources of light are also in use *viz.*, fire, oil lamps, candles, gas lamps and electric bulbs etc. In these sources of light, the light is given out by flame or heated filaments.

Such objects which give off their own light are called LUMINOUS objects.

There are also non-luminous objects which do not produce any light. Most of the objects are non-luminous. The walls, the trees, the bench and even human bodies are non-luminous. They are visible only because of light energy which falls on them from other luminous objects, which they reflect to our eyes. Different parts of the object reflect differently, thus defining the shape and size of the object. The moon, for example can only be seen by the light energy that falls on it from the sun.

Some non-luminous bodies can be made luminous. A piece of charcoal is non-luminous but when it burns, it gains luminosity.

In an electric bulb the filament is cold and non-luminous. But as soon as you turn on the switch, electric

current flows through the filament and it becomes very hot and luminous.

4.3. Transparent and Opaque Bodies

Substances through which light can pass are called *transparent*. Air, clean water, plastics, glass are transparent bodies.

Substances which allow only part of light to pass through are called *translucent*. Ground glass, oil paper, thin polythene sheets are called translucent.

Substances which do not allow the light to pass through them are called *opaque*. Wood, metal, brick, book, etc., are examples of opaque bodies.

Activity 4.1

Find out through which of the following substances you are able to see the source of light. List these substances as opaque, transparent and translucent in the following table :

A sheet of glass, water, polythene sheet, wood, steel plate, glycerine, kerosene oil, book, greased paper, grounded sheet of glass.

Opaque	*Transparent*	*Translucent*

4.4. Light Travels in Straight Lines

The light coming out of your torch, the headlight of a car and sunlight, entering a dark room through the hole of a window, all follow a straight path.

Generally, sunlight entering a room through a slit is not visible, but if a dusty cloth is shaken or if the room is filled with smoke, the path of the light becomes visible.

Activity 4.2.

Take a wooden box of suitable size. Fit a transparent glass plate on

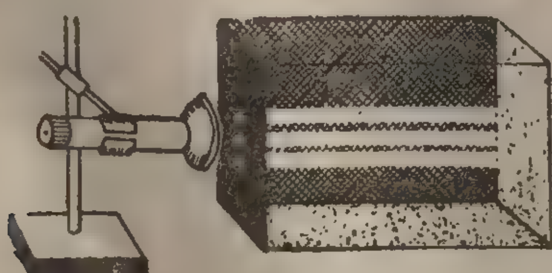


Fig.4.1: Light travels in a straight line.

the top of the box. One of the shorter side faces of the box is open. Cover this side with a sheet of black paper.

Fill the box with smoke. Make a few pin-holes on the black paper pasted on the shorter side. Hold a torch in front of the holes and look through the glass on top of the box. Observe that the light rays made visible by smoke appear in straight lines. For better results, perform the experiment in a dark or semi-dark room.

Through experiment, it has been found that in vacuum light travels with a velocity of about 300,000 km per sec. Velocity of light is very high as compared to that of sound. Velocity of light is not the same for ever medium. It is slightly less in air than in vacuum. In water it is 1·33 times less than in vacuum and in glass it is approximately 1·5 times less than in vacuum. The medium in which the speed of the light is less than in vacuum is called an *optically denser medium*. Therefore, glass and water are optically denser than air, while glass is optically denser than water.

4.5. Shadows and Eclipses :

It is a well-known fact that opaque objects cast shadows. When you walk in the sun, the shadow cast by your body moves along with you. The size of your shadow depends on the time of the day. In the early morning or in the afternoon, your shadow looks very long, while at noon the shadow is very small. This is because the sun is directly overhead.

Size of a shadow cast by an object depends on the relative positions of the source of light, the object and the screen on which the shadow is cast.

6.6. Variation of the size of a shadow with the size of source of light

In the Fig. 4.2, L is the point source of light. AB is the object and A'B' represents the shadow formed on the screen.

In this case the shadow is dark and well-defined.

Now consider the case if the source of light is bigger than the size of the opaque body.

In Fig. 4.3, S represents the

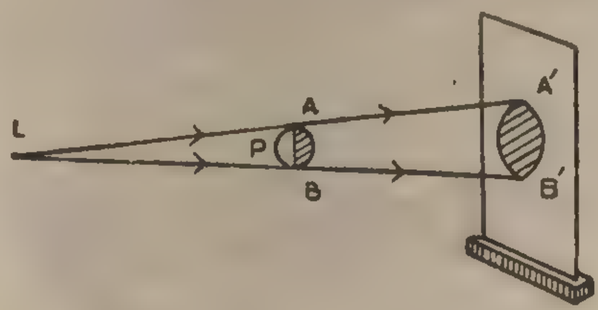


Fig. 4.2. Shadow due to a point source of light.

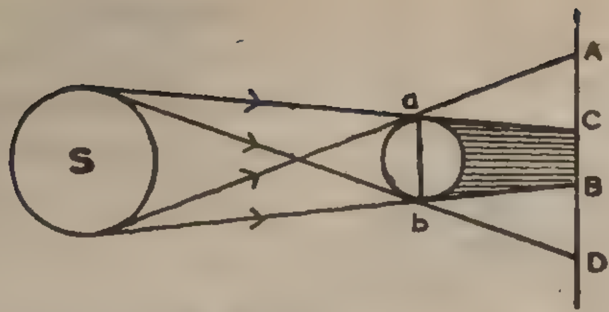


Fig. 4.3. Formation of Umbra and Penumbra

source of light and ab the object. The shadow is represented by ACBD. Regions AC and BD are partially dark and are called *penumbra* of the shadow but BC is completely dark and is called *umbra.*

If the screen is now shifted away from the object, the size of the penumbra will increase while that of umbra will decrease and finally disappear.

47. Solar and Lunar Eclipses

Large opaque bodies like the moon and the earth cast shadows leading to the phenomenon of eclipses. The moon revolves round the earth while the earth revolves round the sun. In doing so, sometimes the moon comes in between the earth and the sun and its shadow falls on the earth. This causes the *Solar Eclipse* (Fig. 4.4).

The portion of the earth falling completely under umbra has total eclipse while the other portions of the earth observe partial eclipse of the sun.

The lunar eclipse (Fig. 4.5) occurs when the sun, earth and moon are in a straight line with the earth between the sun and the moon. If the moon is in the umbra cone of the earth, it will not be visible because the moon is non-luminous and can only be seen by the light that falls on it from the sun.

By measurements and calculations of the paths and speeds of the earth and the moon, astronomers can tell the dates of the lunar and solar eclipses long before they actually occur and their dates and times are published well in advance in scientific journals and newspapers.

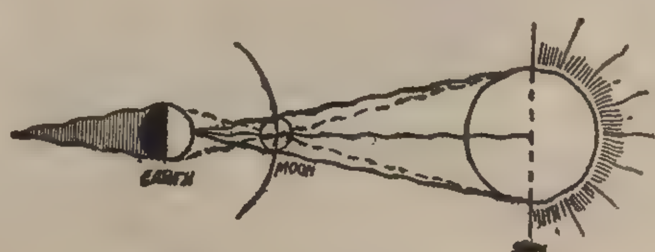


Fig. 4.4. Solar Eclipse

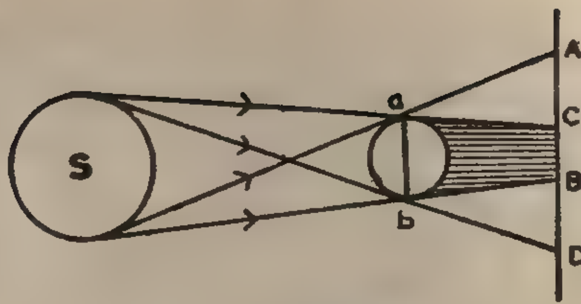


Fig. 4.5. Lunar Eclipse

4.8. Pin-hole camera

It consists of a rectangular wooden or card board box, on the front side of which there is a small hole in the centre. A ground glass screen is provided at the backside. For better result paint the inner surface of the box, black.

AB represents the flame of a candle, H the pinhole and A′B′ the image of the candle flame.

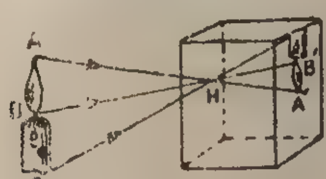


Fig.4.6. Pin-hole camera

The camera is so placed that the centre of the screen, the pinhole and the centre of the flame are in one straight line.

Due to rectilinear propagation of light, rays from the point A and B pass through the pinhole and meet the screen at A′ and B′.

A real, inverted image of the candle flame is formed on the screen. The image is quite sharp and clear.

Activity 4.3.

Measure the size of the flame, and on the screen, mark the height of the image. Also, measure the distance HB and HB′. Change the distance HB between the pin-hole and the flame. Again measure the size of AB, A′B′, BH and HB′. In each case you will observe that :

$$\frac{HB'}{HB} = \frac{A'B'}{AB}$$

4.9. Reflection of light

When light falls on a body, three things can happen to the light :

(*a*) It can be sent back into the medium from which it was coming ; that is it can be **reflected**. It is this reflected light coming to our eyes that enables us to see the body.

(*b*) It can be allowed to pass through the body ; that is, it can be **transmitted**. Only transparent and translucent bodies allow this, but different transparent and translucent bodies transmit different amounts of light.

(*c*) It can be **absorbed**. All bodies absorb light, but they absorb different amounts of it.

Every object reflects light but the amount of light reflected is different for different objects. One of the best reflectors of light is the **plane mirror** which can easily be produced by painting or silvering one side of plane glass. *Any highly polished surface can be a good reflector and is called a mirror.*

4.10. Regular and irregular reflection

If you hold a plane mirror and a sheet of cardboard in front of you, you will see your face in the mirror but not in the cardboard, and yet both objects are reflecting light. The fact is that the mirror is reflecting the light regularly, as shown in Fig. 4.7 (*a*) while the cardboard reflects it irregularly, *i.e.*, scatters it, as in Fig. 4.7 (*b*). It is possible with the former to form an image which appears behind the mirror, as you will see later, but the cardboard cannot form an image. In the same way the rough surface of a table scatters light but when it is polished the tiny holes are filled with polish so that the table now reflects light regularly and you are able to see your face in it.

Activity 4.4.

To test the truth of the laws of reflection.

Requirements : A mounted plane mirror, a ray apparatus, four pins and paper.

N.B. *The ray apparatus* is a piece of apparatus consisting of a lamp, a

(*a*) *Regular* (*b*) *Irregular*

Fig. 4.7. Reflection

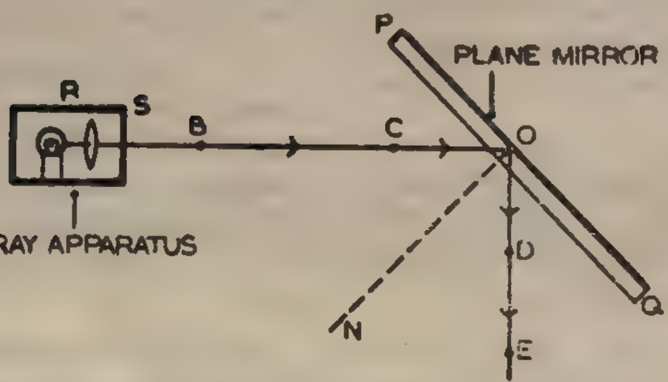


Fig. 4.8. Testing the truth of the law of reflection (1st method).

lens and a slit or slits arranged in such a way as to produce a very narrow beam of light commonly called a ray of light.

By using more than one slit it is possible to produce more than a single ray.

Procedure : Ist Method. Arrange the mounted plane mirror PQ (Fig. 4.8) so that it stands on one of its long edges, on a sheet of paper. In front of it place the ray apparatus R and use slit S to produce a single ray of light. Arrange this ray to strike the mirror. You will notice that it is sent back or *reflected* by the mirror. With a sharp pencil, mark two points B and C along the ray that goes to the mirror. This ray is called the *incident ray*. Mark two other points D and E along the ray that is sent back by the mirror. This ray is called the *reflected ray*. Now trace on the paper the position of the mirror PQ. Remove the mirror ; join the points B and C, and then the points D and E. Produce the two lines to meet at O.

Do your lines meet exactly on the line PQ ? They don't. This is because the back of the mirror, and not the front, is the reflecting surface. The lines should meet at the silvered back of the mirror.

Through the point O, use your set square to draw a line ON perpendicular to the mirror. Such a line is called the *normal* to the mirror. Also through O draw a line parallel to PQ. This line is the silvered back of the mirror where the reflection actually takes place.

Now measure the angle BON known as the *angle of incidence* and the angle EON known as the *angle of reflection*. What do you notice ?

Repeat the experiment twice using different angles and record your results

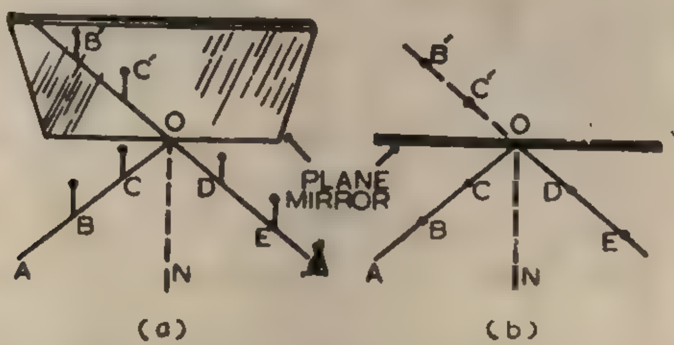


Fig. 4.9. Testing the truth of the law of reflection (2nd method)

Experiment		Angle of incidence BON	Angle of reflection EON
(*i*) Ray experiment	1.		
	2.		
	3.		
(*ii*) Pin experiment	1.		
	2.		
	3.		

as shown above.

2nd Method. Place the mirror on the paper as in the first instance. Draw a slanting line AO to meet the mirror at O (Fig. 4.5). Stick two pins B and C vertically on this line. Now set your eye along the direction shown in the diagram. You will see the images B′ and C′ of the pins in the mirror. Set your eye in the line with these two images and stick two other pins D and E on the paper in front of the mirror such that they are both in line with B′ and C′. Now remove the mirror and the four pins after marking the position of each. Join BC, ED and produce them to meet at O. Proceed as for the first method. What do you notice again about angles BON and EON ?

Repeat the experiment twice, using different angles of incidence and record your results in a table.

Examine and compare the last two columns of your table. What do you notice ?

Two things can be noticed in these experiments.

(*a*) That the angle BON=angle EON, *i.e.*, the angle of *incidence* is equal to the angle of *reflection*, in every case.

(*b*) That in the ray apparatus method we actually see both the incident ray and the reflected ray on the plane of the paper, and in the pins experiment we actually see the tips of all the pins on the plane of the paper.

These two observations can be summed up by saying that when a ray of light is reflected by a mirror, it obeys these *two laws of reflection.*

(*a*) the angle of incidence is equal to the angle of reflection ;

(*b*) the incident ray, the reflected ray and the normal at the point of incidence all lie in the same plane.

And so with the above experiment we have verified the Laws of Reflection.

Activity 4.5

To find the position of an object placed in front of a mirror.

Requirements. A mounted plane mirror, a ray apparatus, one pin and paper.

Procedure. Set the plane mirror and the ray apparatus as for the last experiment. Let the ray apparatus produce a broad beam of light on the paper. Erect a pin vertically somewhere inside the beam. You will see a shadow of the pin going to the mirror and being reflected (see Fig. 4.10). With your pencil, trace the position of the mirror, mark the points A, B, C and D at the two edges of the shadow going to the mirror and the points E, F, G and H at the two edges of the shadow reflected from the mirror, as shown in the diagram. Remove the mirror. Join AB, CD, FE and HG and produce each to meet the mirror. Produce FE and HG

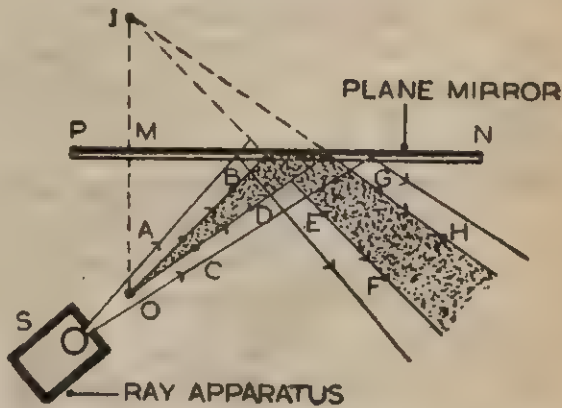


Fig. 4.10. To find the position of an object placed in front of a mirror

behind the mirror to meet at I. Draw the Reflecting surface PN as you did in the last experiment. Join OI and

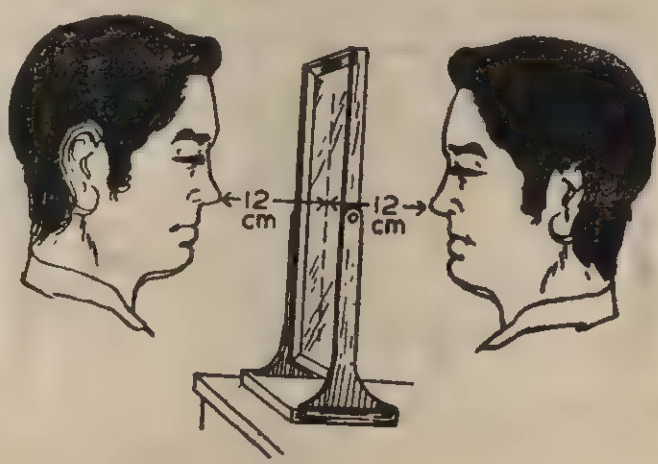


Fig. 4.11.

let it meet PN at M. Measure MO, MI and the angle IMN. What do you notice ?

Repeat the experiment twice.

If your experiment has been carefully done you will find that MO is equal to MI and that angle IMN is 90°. Thus you have found out that *the image of an object is as far behind the mirror as the object is in front of it.*

When next you look at your face in a mirror you can tell your friend exactly where the image of your face is (Fig. 4.11).

4.11. How to find by geometrical construction the position of the image of an object placed in front of a plane mirror

Let MM be the plane mirror (Fig. 4.12) and AB the object in front of it. With the help of a set square draw AX and BY perpendicular to MM′. Produce AX to K and BY to L behind the mirror. Using a pair of compasses, with X as centre and radius equal to AX, draw an arc to cut XK at A′. Again, with Y as centre and radius equal to YB, draw another arc to cut YL at B′. Join A′B′. A′B′ is the image of object AB. Try and explain why this is so.

4.12. Lateral inversion

If you look at yourself in a mirror while writing on a sheet of paper with your right hand, you will be surprised to notice that you appear to be using your left hand ; further, your left hair parting looks as if it were on the right ; finally, hold what you are writing against the mirror and you will not be able to read your writing ! In general, everything seems to have been turned round the other way ; the right becoming the left and the left becoming the right. *This sideways turning of the image obtained by reflection in a mirror is called* **lateral inversion.**

You may like to try the following exercises :

1. Write something in ink on your paper and blot it immediately. Try to read what appears on the blotter. You cannot read it. Now hold it against the mirror and you can read it clearly.

2. Read the following word first

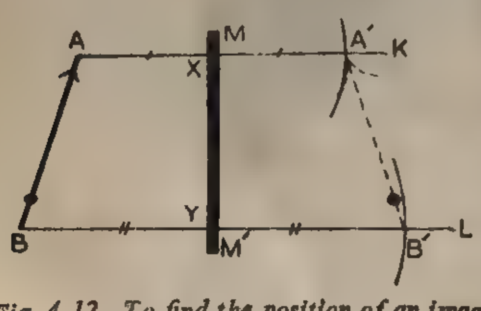


Fig. 4.12. To find the position of an image in a mirror using geometry.

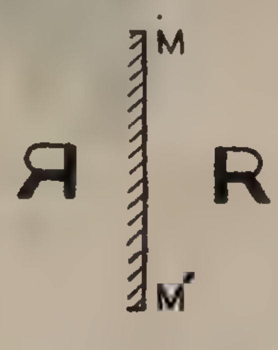


Fig. 4.13. Lateral Inversion

by looking at it directly and then by holding it against the mirror (Fig. 4.13).

3 Try to tell the time by holding your watch or clock against the mirror.

The above three illustrations are further examples of lateral inversion, and you can reason out how it happens in each case.

4.13. Curved (Spherical) Mirrors

So far you have been studying the reflection of light from plane surfaces, but curved surfaces also reflect light. A curved mirror is a small part of the surface of a sphere.

There are two types of curved mirrors : the *concave mirror* and the *convex mirror*.

A well-polished tablespoon may be used to illustrate the two types of curved mirrors. The hollow side of the spoon is a concave mirror, while the backside of the spoon is a convex mirror.

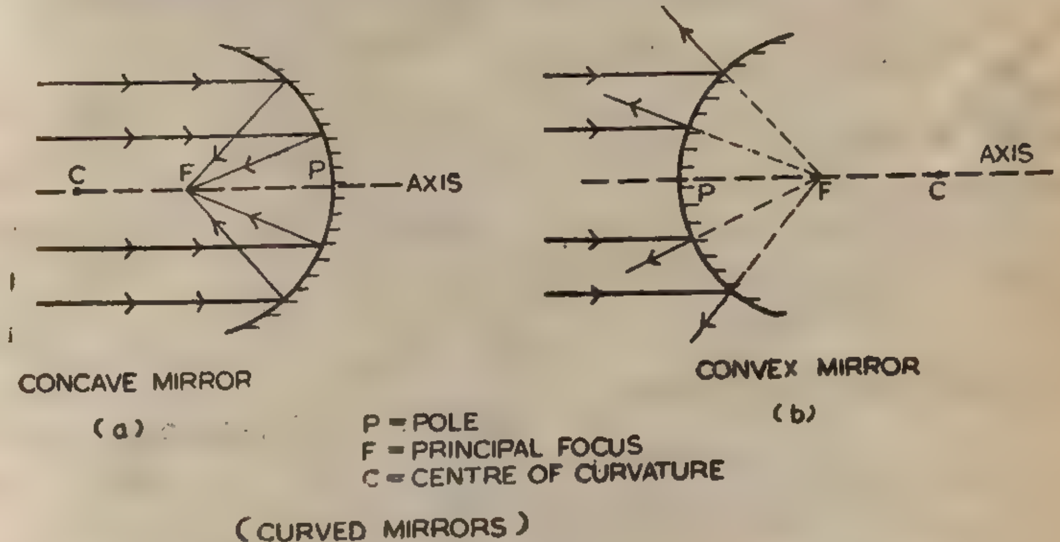


Fig. 4.14.

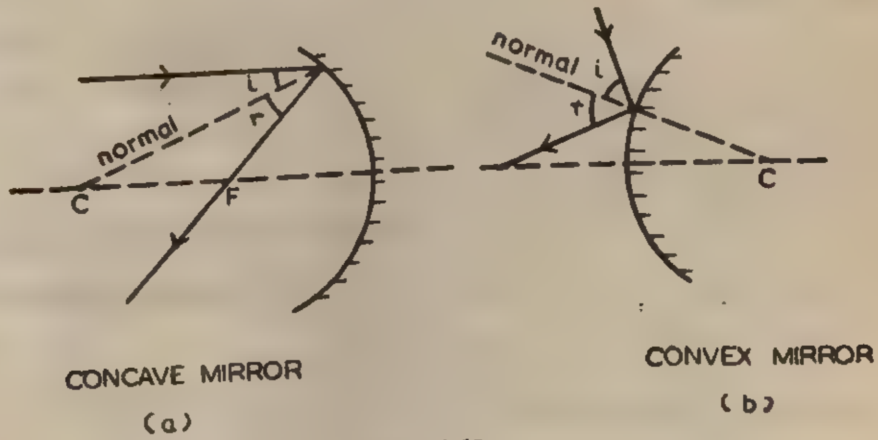


Fig. 4.15.

The pole of a mirror is the centre of the reflecting surface.

The centre of curvature is the centre of the sphere of which the mirror is a part.

The radius of curvature r is the radius of the sphere of which the mirror is a part.

The principal axis is the line joining the pole and the centre of the curvature.

The principal focus is the point on the principal axis through which rays parallel to the principal axis are reflected (concave mirror) or from which the rays appear to come after reflection (convex mirror).

The focal length f is the distance between the principal focus and the pole (centre) of the mirror.

Graphical construction of images

The position and size of an image can be found graphically by using any two rays drawn from the top of the object.

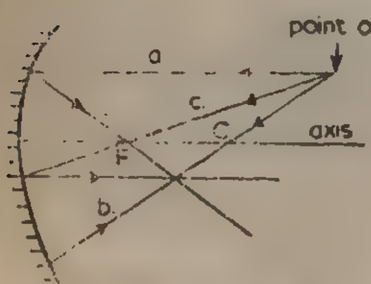


Fig. 4.16. Three rays used to construct images

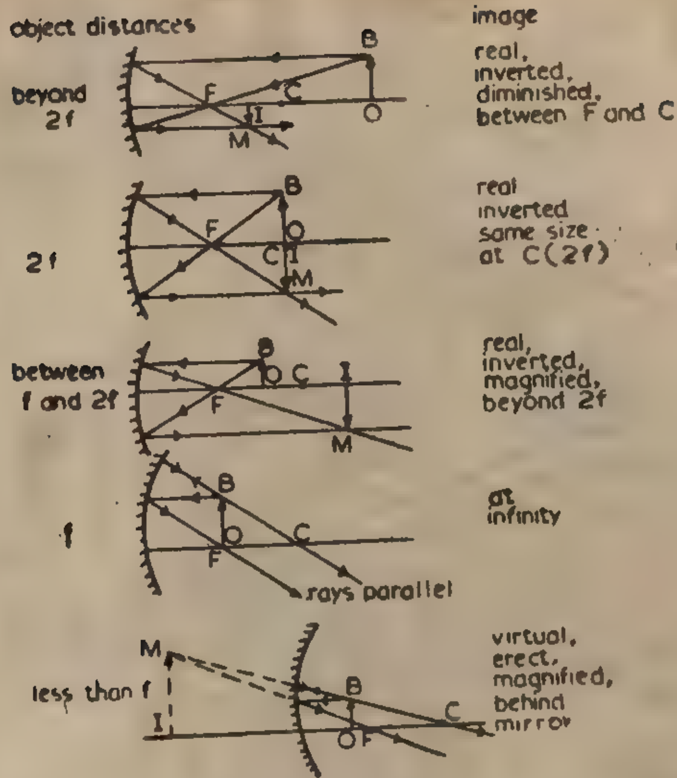
	Before reflection	*After reflection*
(*a*)	Parallel to principal axis	Through the focus (concave) From the focus (convex)
(*b*)	Through or towards centre of curvature	Back along its own path
(*c*)	Through or towards focus	Parallel to axis

Images formed by concave mirror (focal length f)

Object distance	*Image distance*	*Character of image*
Infinity-2f	f-2f	Real, inverted, smaller
2f	2f	Real, inverted, same size
2f-f	2f-infinity	Real, inverted, larger
f	infinity	No image, Parallel beam
Less than f	Behind mirror	Virtual, erect, larger

Images formed by convex mirror

They are always *virtual*, *erect* and *smaller*.



... images formed by concave mirror.

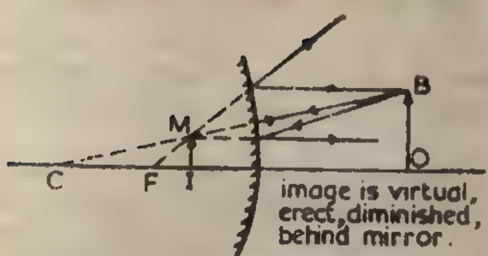


Fig. 4.18. Image formed by convex mirror

How can you tell the difference between a concave and a convex mirror? The following illustrations will enable you to distinguish between these two types of mirrors :

1. In a concave mirror the outer surface is silvered, while the inner hollow surface is the reflecting surface. But in a *convex* mirror the outer surface is the reflecting surface, while the inner, hollow surface is silvered (Figs. 4.17 and 4.18).

2. Hold the mirror near your face and look at your face in it. Gradually move the mirror away from you while you fix your eyes on the image of your face in the mirror. If it is a *concave mirror*, when the mirror is near your face you will see an *enlarged* and *upright* image of your face ; as you move it away from you the image gets larger and larger, until it seems to disappear and then reappears still as an *enlarged* face but now *inverted*. As the mirror is moved farther away the image remains *inverted*, but gets

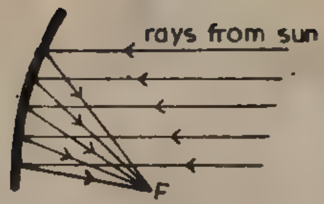


Fig. 4.19. Concave mirrors the sun's parallel rays to the focus.

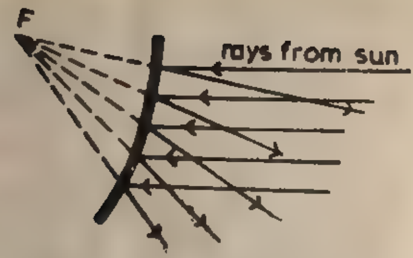


Fig. 4.20. Convex mirrors diverge the sun's parallel rays. A focus is obtained by producing the reflected rays backwards.

smaller and smaller.

If it is a *convex mirror* you will see an *upright* and *diminished* image of your face wherever you place the mirror, but this image gets smaller and smaller as you move the mirror away from you.

3. Hold a concave mirror towards the sun and direct the beam reflected by it to a piece of carbon paper or a piece of cloth. Move the paper to and fro until a sharp image of the sun is obtained on the paper. What happens to the paper ? To get a good effect the experiment must be performed under bright sunshine.

You will find out that the paper starts to burn as soon as a *sharp* image of the sun is focused on it.

Now try the same experiment with a *convex mirror*. What do you notice ? You will find out that no matter how long you hold the mirror and no matter where you place the paper, the paper will not burn and the image of the sun will not appear on the paper.

Explanation : The concave mirror collects all the rays that get to it from the sun and converges them on the paper, forming a *real image* of the sun on the paper. Both the light and the heat of the sun are thus focused on the paper, and therefore the paper burns (see Fig. 4.19). But in the case of the convex mirror it diverges the rays that reach it from the sun (Fig. 4.20) so that the rays cannot meet to form a real image of the sun in front of the mirror. Because of this effect of the mirrors on the sun's rays, the concave mirror is sometimes called a *converging mirror* and the convex mirror a *diverging mirror*.

The sun is so far from the earth that rays coming from it can be said to be parallel. Hence in Figs. 4.19 and 4.20 the sun's rays are drawn as parallel rays. The point where the sun's rays meet after being reflected from the concave mirror is called the *focus* of the concave mirror, while the distance between the mirror and this point is known as the *focal length* of the mirror. Since the sun's rays actually meet at this point, this focus is a *real* focus and the image of the

sun collected on the paper is a *real image.* It is diminished.

When the sun's rays reflected by the convex mirror are produced behind the mirror they will meet at a point F (Fig. 4.20). This point is the *focus* of the convex mirror, and the distace between the mirror and the focus is the *focal length* of the mirror. The sun's rays do not actually get to this point, they only seem to proceed from the point. Hence the focus is a *virtual* focus and the image of the sun formed at this point, which you can see only by looking into the mirror, is a virtual image, as in the case of the plane mirror.

4.14. Some uses of curved mirrors

1. Concave mirror for shaving :

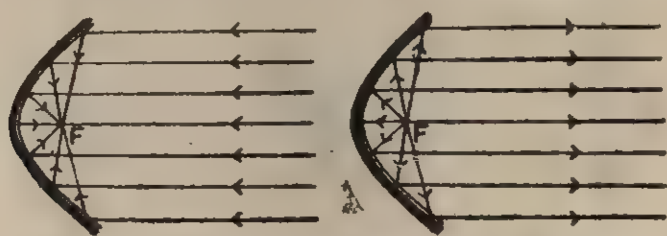
To shave properly it is useful to have an enlarged image of your face. This is done by holding a concave mirror close to the eye, where the image of the face is upright and enlarged.

2. Parabolic mirrors as reflectors in torch lights and car head lights.

We have seen from an earlier experiment that when parallel rays come to a concave surface they are converged to a point known as the focus [Fig. 4.21 (*a*)] Now if a diverging beam starts from the focus and reaches the mirror it will be reflected as a parallel beam [Fig. 4.21 (*b*)], This can be used to obtain a parallel beam of light which can travel far. Thus, if a strong lamp is placed at the focus of a concave mirror a *searchlight* can be made which at night will spot an aeroplane hundreds of metres above the ground. This type of concave mirror is of parabolic shape and is used in car head-lamps and torchlights.

In a *torchlight* and in *car head-lamps* the lamps are generally placed at the focus of the parabolic mirror, which acts as the reflector. In this position a parallel beam of light is produced.

In some torches it is possible, by turning the screw cover, to move the electric bulb in order to vary the position of the bulb and thus the nature of the beam produced. By thus changing the position of the bulb



(*a*) *Converging to the focus* (*b*) *Reflected from the focus*
Fig. 4.21. Parallel rays

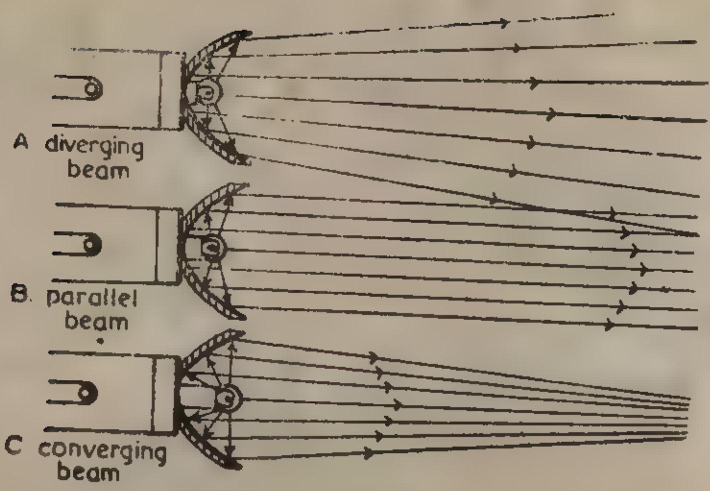


Fig. 4.22. Torchlight produces different beams of light

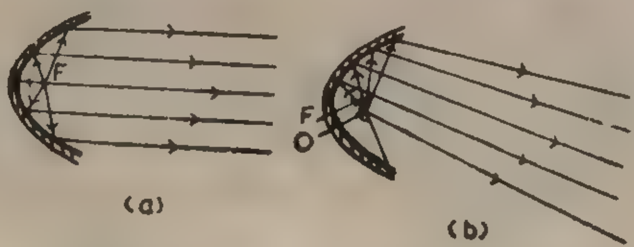
it is possible to obtain a converging beam, a parallel beam and a diverging beam (see Fig. 4.22).

You will see this effect very well if you direct the beam to a wall.

In car headlights this moving to and fro is not desirable. When another car is approaching in the evening it is good manners to 'dip' one's lights. To do this the beam, which is normally parallel, must be made to dip down. This is done not by moving the bulb to and fro but by lighting another filament below the main one farther from the mirror than the focal length of the mirror and hooded to prevent light being reflected upwards [Fig. 4.23 (*a*) and (*b*)].

3. Convex mirror in motor cars

Convex mirrors form small images and so give a wide range of view. They are therefore, used in cars to enable the driver to see another car approaching him from behind. A plane mirror can also be used, but the field of view is not as large as in the case of the convex mirror. A concave mirror cannot be used, as its field of view will be too narrow.



(a) Full light. *(b) Dipped light*

Fig. 4.23. 'Dipping' the lights of a car

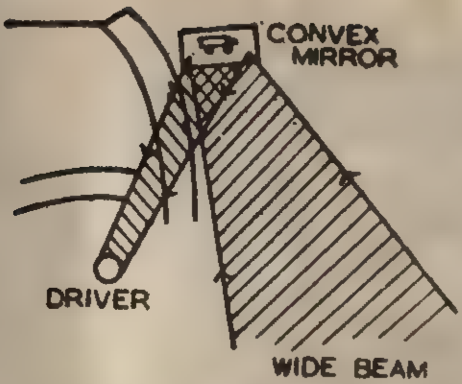


Fig. 4.24. Driving mirror—convex

4.15. Spherical Lenses

A lens is a piece of transparent substance enclosed by two surfaces, one spherical and the other spherical or plane. *Convex* (*converging*) *lenses* are thicker at the centre than at the edges. *Concave* (*diverging*) *lenses* are thicker at the edges than at the centre.

The *principal axis* of a lens is the line passing through the centre of each surface.

To observe images formed by lenses

Concave lens. Look through a concave lens at a near object and men at a distant object.

Convex lens

1. Hold a convex lens close to the printed page of a book.

2. Slowly increase the distance between the lens and book (object distance).

3. Look at a distant object through a convex lens held at arm's length from your eyes.

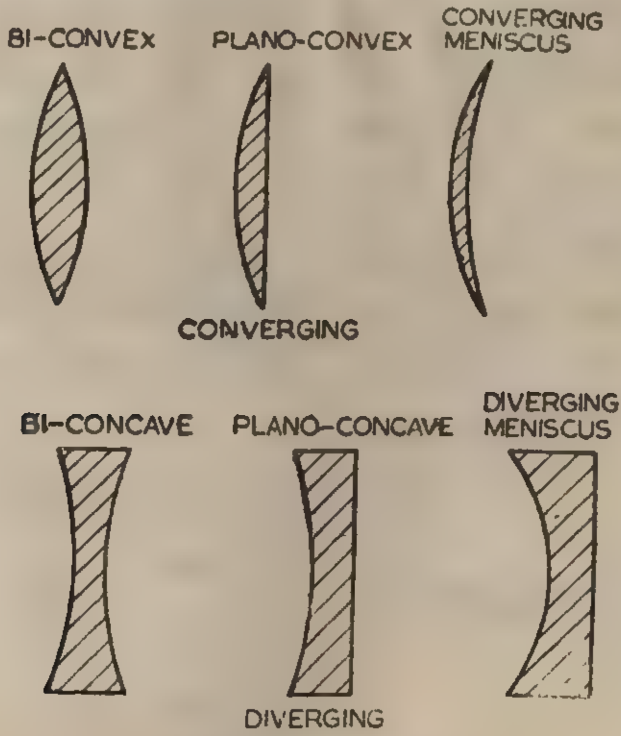


Fig. 4.25. Lenses

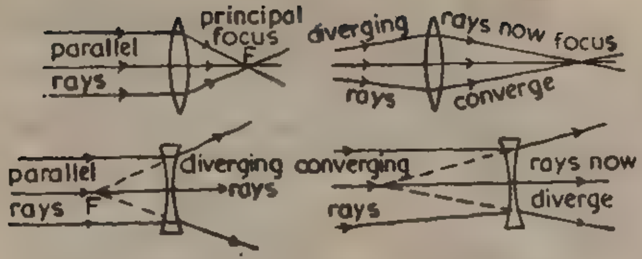


Fig. 4.26. How lenses refract

The principal focus of a lens is the point of the principal axis to which rays parallel to the axis converge after refraction (convex lens) or from which the rays appear to diverge after refraction (concave lens). The focal length of a lens is the distance between the principal focus and the centre of the lens.

The principal focus of a convex lens is real because (*a*) it can be seen on a screen, and (*b*) rays of light pass through it. The principal focus of a concave lens is *virtual*. Thicker lenses refract light more and have shorter focal lengths than thinner ones. A lens has a principal focus on both sides. They are the same distance from the lens which has only one focal length.

How a lens acts

A lens acts as a number of prisms. A prism refracts light towards its base. The outside 'prisms' of a convex lens have large refracting angles and refract the light inwards more than the central 'prisms'. Therefore the rays converge. A concave lens makes the rays diverge.

To measure the sizes of images formed by a lens

Place a convex lens vertically in a lens holder. Place a luminous object (*e.g.*, a burning candle or cross-wires illuminated by a ray box) about one metre from the lens. Move a white screen on the other side of the lens until a sharp image is formed on it. The image is *diminished*, *inverted* and *real*.

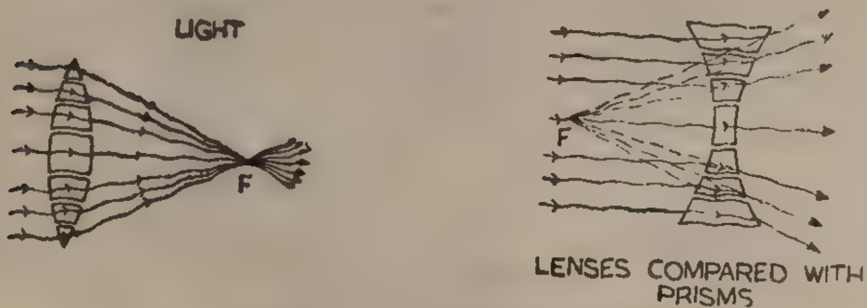


Fig. 4.27. A lens acts like many prisms

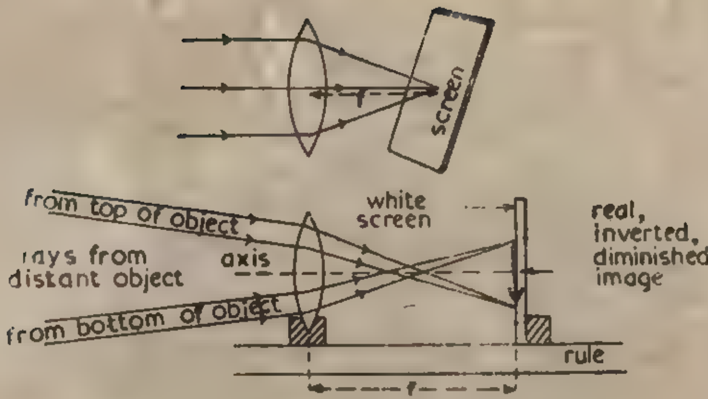


Fig. 4.28. Focal length of converging lens

Move the object towards the lens. The image is larger and further away from the lens, *i.e.*, the image distance increases. Move the object nearer still to the lens. At some places, no image can be formed on the screen (the image is virtual).

Measure the sizes and distances of the object and image formed in various positions. Use your results to confirm this formula :

$$\frac{\text{Size of image}}{\text{Size of objects}} = \frac{\text{distance of image from lens}}{\text{distance of objects from lens}}$$

To find the focal length of a converging lens

Using distant object. Hold a convex lens in sunshine so that light passes through it to a white screen. Move the screen until a small sharp spot of light forms on it. Measure the distance between the screen and the centre of the lens. This is the focal length. The screen may start to burn if the sun's rays are powerful, because heat rays also come to a focus. Repeat several times. The average of the readings is the focal length, f.

Graphical construction of images

The position and size of an image can be found graphically by using two rays drawn from the top of the object.

Before refraction	*After refraction*
1. Parallel to principal axis	Through the focus (convex) From the focus (concave)
2. Through centre of lens	Goes straight on
3. Through or towards principal focus	Parralel to axis

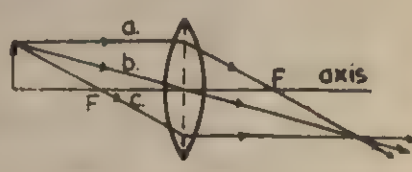


Fig. 4.29. Three rays used to construct images

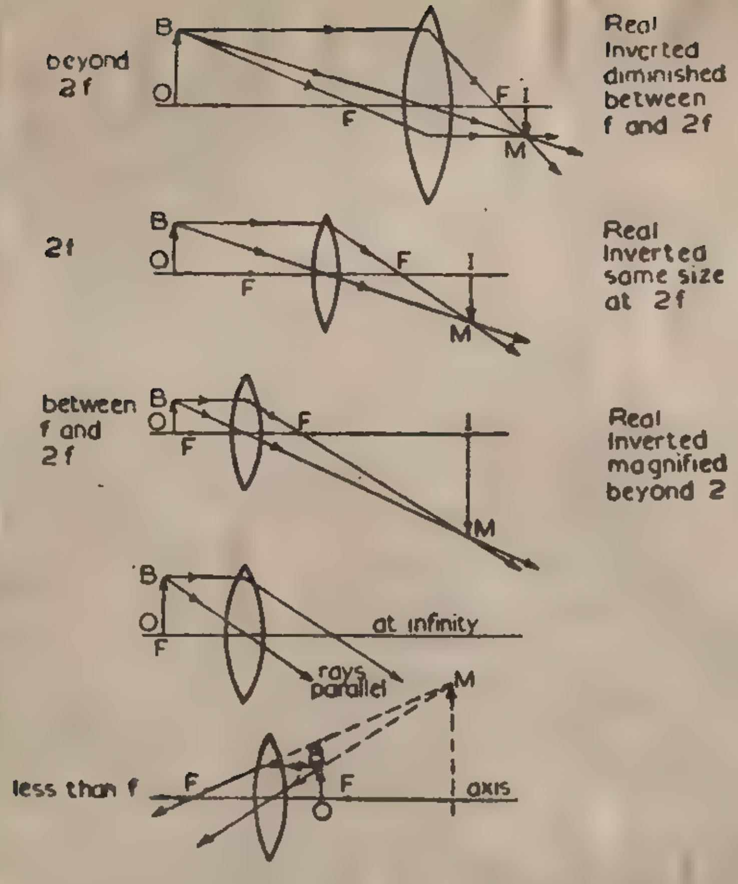


Fig. 4.30. Images formed by convex lens

Images formed by convex lens (focal length f)

Object distance	*Image-distance*	*Characteristics and uses of image*
Infinity —2f	f—2f	Real, inverted, smaller Eye and camera
2f	2f	Real, inverted, same size Copying camera
2f—f	2f—infinity	Real, inverted larger, Photographic enlarger and projection lantern
f	Infinity	No image. Parallel beam Searchlights
Less than f	Greater than object-distance	Virtual, erect, larger Magnifying glass.

Note that as the object distance becomes smaller the image distance becomes larger. The image and object are always on opposite sides of the lens except when the object distance is less than f (last example above).

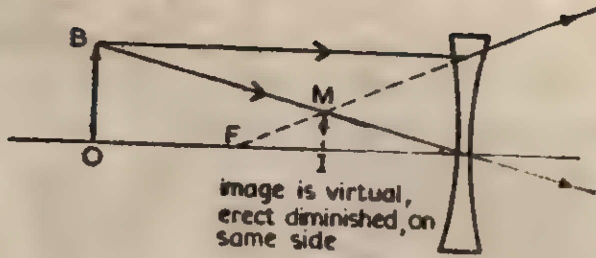


Fig. 4.31. Image formed by concave lens

Images formed by concave lens

The image is always *virtual*, *erect* and *diminished.*

4.16. To use a convex lens as a magnifying glass (*Simple Microscope*)

Open a page of your book and hold a convex lens between the book and your eye. First hold it very close to the book and then gradually move it towards your eye. Record your observations.

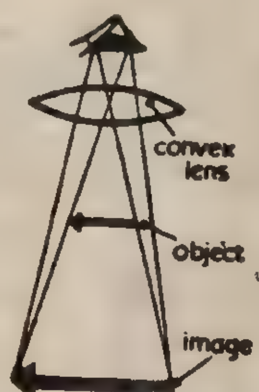


Fig. 4.32. A convex lens as a magnifying glass.

You will notice the following :

(*a*) that the letters in the book are just about the same size when the lens is moved very close to them, but that they get rapidly bigger and bigger as the lens is gradually moved up towards the eye ; they remain erect throughout ;

(*b*) that a point is reached when the letters can no longer be seen through the lens, but that a little later the reappear as inverted, large letters which now begin to get smaller.

Explanation : You have learnt how the lens formed the images of the objects (letters). But it is useful to note here that the *erect, enlarged* images of the letters (Fig. 4.32) seen through the lens are *virtual* (*i.e.*, they cannot be collected on the screen) and that we get such images only when the object is between the lens and its focus.

4.17. The concave lens

If you try to perform the above experiments with a concave lens you will obtain entirely different results.

In the first place, your paper or cloth will not burn no matter how long you hold the concave lens above it, under the brightest sunshine. As has been shown before, only *virtual* image of the sun will be formed, and so it cannot be collected on the cloth or on the screen.

Secondly, no matter how much we try, no image of the well-lit house or tree can be collected on the screen by

a concave lens. Thirdly, the letters of a book seen through a concave lens appear smaller in size but they remain erect, as in the case of the convex lens. They appear smaller and smaller as the lens is moved nearer to the eye.

The concave lens forms a *virtual*, *erect* and *diminished* image of all objects placed in front of it and at any distance from the lens. You will learn in higher classes how these images are formed.

4.18. Some uses of lenses (Optical Instruments)

Lenses are used very widely in almost all optical instruments. A few of these will be discussed here.

1. *As a magnifying glass.* Convex lenses can be used in reading, to magnify small print.

They are used as hand-lenses in biology to examine the minute structure of leaves and other tissues which the normal eye cannot easily see.

They are used by watch-repairers and goldsmiths to enable them to see the very tiny things they have to handle.

They are attached to covers of small watches, especially those with dates, to enable the date to be read easily.

They are also used to read thermometers and barometers and other measuring instruments when the graduation lines are so close that the eye cannot easily read them.

2. *The photographic camera.* Convex lenses are used in the camera. This consists chiefly of a convex lens and a sensitive film or plate forming the screen, all being enclosed in a box painted black on the inside to prevent any light affecting the film. Fig. 4.33 shows the working of a folding camera. EGHF is the camera, O being the camera lens and GH being the film or plate. AB is the object whose photograph is being taken. A beam of light from it passes through

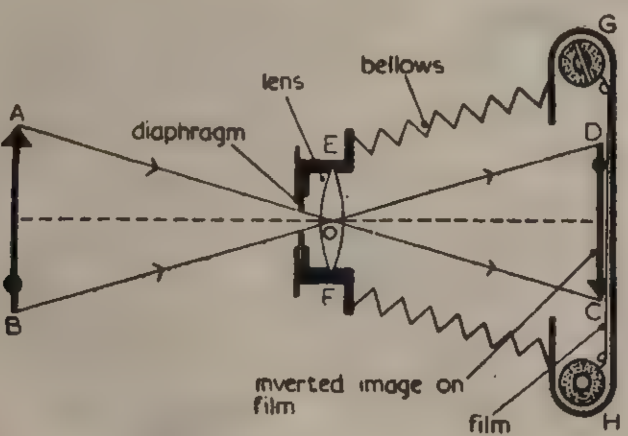


Fig. 4.33. Diagram of a folding camera.

the lens and forms an inverted image of the object on the sensitive film or plate. You 'take' the photograph by allowing light to pass through the lens for a very short time, depending on how much light is available. This light will affect the film or plate according to how much of it reaches different parts of the film, that is, according to the image of the object formed on it.

After the photograph has been taken the film is removed in the dark room and treated first with a chemical solution known as the developer and then with the fixer. It is then brought out and dried. The product is called the *negative*.

By allowing light to pass through this negative on to a sensitive card known as the printing card, a *positive* can be obtained. This positive is the finished product commonly called the *photograph* of the object. You should visit a photographer's dark room to watch these processes of developing and printing.

Some parts of the camera are worthy of note.

(*a*) *The shutter*, *i.e.*, the window which opens only for a fraction of a second to admit light. This is operated by the photographer when everything is set.

(*b*) *The diaphragm*, *i.e.*, the stop which controls the hole through which the light enters the camera. This hole can be made narrower or wider to control the amount of light coming into the camera. In dull weather it is widened, while in bright sunshine it is made narrower and smaller.

(*c*) *The bellows.* This is made of leather blackened inside and outside. It is used to focus the image on the film or plate. This means that it is used to move the screen (*i.e.*, the film) to and fro until the sharpest image of the object is produced on it. Cheap box cameras have no bellows, and so on focusing can be done, since the distance between the lens and the film is fixed.

3. *The Eye.* Look at the eye of a human being, ox, sheep, rabbit, etc.

Parts of the Eye

The eyeballs are the organs of sight. They are in bony orbits of the skull, and are also protected by eye-brows. Each eyeball can be moved by six muscles. An eyeball has three coats : sclerotic, choroid and retina.

(*a*) *Sclerotic* is the opaque tough coat called the white of the eye. At the front is the transparent window, the *cornea.* The sclerotic protects the delicate parts inside.

(*b*) *Choroid.* This black coat contains blood vessels that supply food and oxygen to the eye. It absorbs stray light in the eye. It thickens and forms *ciliary muscle* at the front.

(*c*) *Retina.* This covers the side of the eye. Its many nerves pass light impulses to the optic nerve, which then transmits them to the

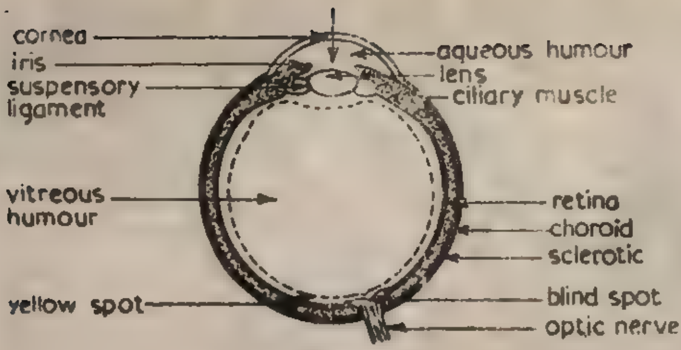


Fig. 4.34. The Eye.

brain. The brain interprets the impulses. Images on the retina are inverted but the brain 'sees' them correctly.

(*d*) *Blind spot.* This is at the point where the optic nerve leaves the retina. Demonstrate it by making two marks, 7 cm apart, on paper. Hold it at arm's length and gradually bring it to one eye, with the other eye closed. Look at one of the marks. When the image of the other is at the blind spot, you do not see it.

(*e*) *Yellow spot.* This is the spot of clearest and most distinct sight. When you look at anything very carefully, its image is at this spot.

(*f*) *Iris.* This is the coloured part of the eye. Light passes through a hole, the *pupil*, in it. The iris makes the pupil narrow in bright light and wide in dull light and thus prevents damage to the eye. Its action is automatic (a reflex action) and cannot be controlled.

(*g*) *Aqueous humour.* This is a watery liquid between the cornea and the eye-lens. It refracts the light.

(*h*) *Vitreous humour.* This is a jelly-like liquid between the eye-lens and retina which keeps the eye-ball in shape. It also refracts the light.

(*i*) *Eye-lens.* This is soft, elastic and convex (converging). Ciliary muscles which pull on ligaments make it thicker or thinner and it therefore focuses the image on the retina.

(*j*) *Optic nerves.* These are the nerves of sight which join the nerves of the retina to those in the brain. These are of two types—the *rods* which are sensitive to dim light and *cones* which are sensitive to bright light and the colours.

(*k*) *Accommodation* is the focusing of an image by alteration of the thickness of the eye-lens. Normally, people can accommodate to focus images of objects between 25 cm. and infinity from their eyes. The power of accommodation decreases as people become older.

The eye and the camera

Similarities are :

Camera	*Eye*
Convex lens	Convex lens
'Stop' controls light	Iris controls light
Shutter keeps out light	Eye-lids keep out light
Image forms on film	Image forms on retina
Black paint stops internal reflexion	Black layer (choroid) stops internal reflexion
Air (transparent) between lens and film	Jelly (transparent) between lens and retina

Both form small, inverted images

Differences are :

Camera	*Eye*
Lens is hard glass	Lens is soft and elastic
Thickness of lens does not change	Thickness does change
Usually, image is focused by moving the lens	Image is focused by making the lens thicker
Only the lens refracts (bends) the light	The aqueous and vitreous humours also refract
'Stop' can be altered.	Iris alters by itself

Why you need two eyes

Close one eye. (*a*) Throw a ball into the air and then try to catch it. (*b*) Hold the arms wide apart, with one finger of each hand sticking out. Bring the hands together so that the two fingers are almost touching. (*c*) Stand a pencil upright on a table. Try to knock over the pencil with a pin. Is it easy to do these things ?

The images formed by each eye are not identical. The brain interprets the correct idea of depth or distance and we 'see' an image in three dimensions. The image formed by one eye is flat like a picture or photograph. A single image seen by both the eyes is called *binocular vision.*

Short sight (Myopia) :

A short-sighted person cannot see distant objects clearly. The eye-lens is too thick (or the eye-ball is too long). Parallel rays come to a focus *in front of the retina.*

Short sight is corrected by spectacles with diverging lenses (concave lenses).

Long sight (Hypermetropia) :

A long-sighted person cannot see near objects clearly. The eye-lens is too thin (or the eye-ball is too short from back to front). Rays from near objects come to a focus *behind the retina.*

Long sight is corrected by spectacles with converging lenses (convex lenses).

Loss of accommodation :

As people grow older, the ciliary muscles lose their power of making the eye-lens thick enough to focus

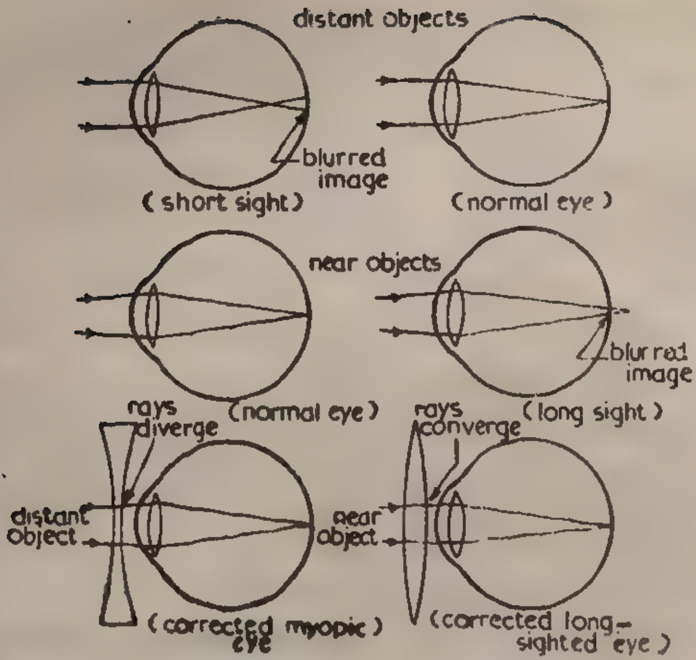


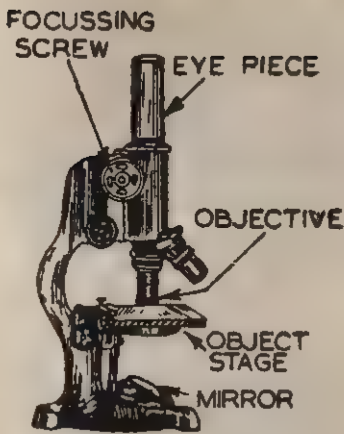
Fig. 4.36. Defects of vision

near objects clearly. Also, the eye-lens becomes less elastic and may not be thin enough to focus distant objects clearly. An older person usually requires spectacles for reading, and may also require other spectacles for looking at distant objects.

The structure of eyes of all animals having back-bone is the same as ours. But in the case of some animals like cow, dog, horse etc., where eyes are present on each side of the head, one eye sees objects of one side and the other eye sees the objects of another side. They can focus only through one eye at a time that is, they use only one eye at a time. This is called *monocular vision.* The image formed is flat and thus they are not able to judge the distance between two objects. The insects and a few other animals have compound eyes. Each compound eye is made up of a large number of small units each one comparable to our eye. In bright light each unit forms an independent image. But in dim light all the units together form a single image. Some insects, like the honeybee can see certain rays which are invisible to the human eye.

4. Microscopes, Telescopes and Binoculars :

A **microscope** is an instrument which enlarges an object. In fact, the magnifying lens already discussed is a *simple microscope.* Its magnification is about 5 to 10 times the size of the object. When more than one lens is used it becomes a *compound microscope.* A telescope and binoculars are instruments which make distant



COMPOUND MICROSCOPE

Fig. 4.37.

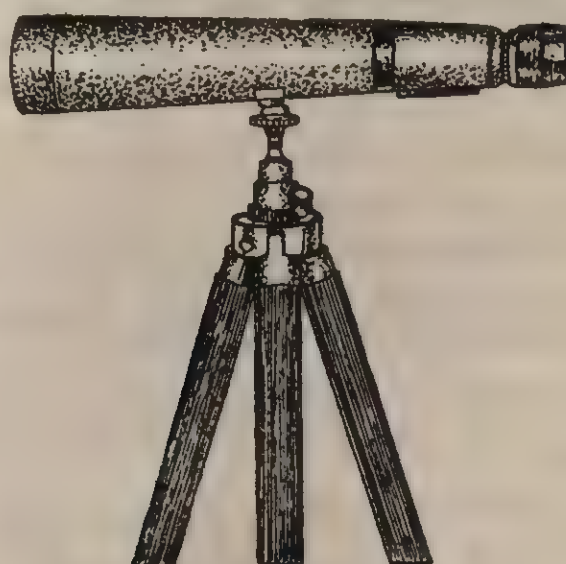
objects bigger and are used to observe the moon, the stars or to watch events taking place some distance away. Telescopes are also used in conjunction with periscopes during warfare.

These instruments are constructed by a suitable combination of two or three lenses. Your teacher will demonstrate them to you and you should examine them closely. You will learn later in your higher studies how the images are formed.

In these instruments the lens that faces the object is called the **objective** and the one next to the eye is called the **eyepiece.** Fig. 4.37 and 4.38 illustrate the compound microscope and the telescope.

In a compound microscope, the objective forms a real magnified image of an object kept just beyond its focal length. The eyepiece acts as a magnifying glass to observe the image formed by the objective. The eyepiece finally produces a highly magnified virtual image of the object.

In a telescope, the objective forms the real image of the distant object at its focus. The eyepiece acts as a



A TELESCOPE

Fig. 4.38.

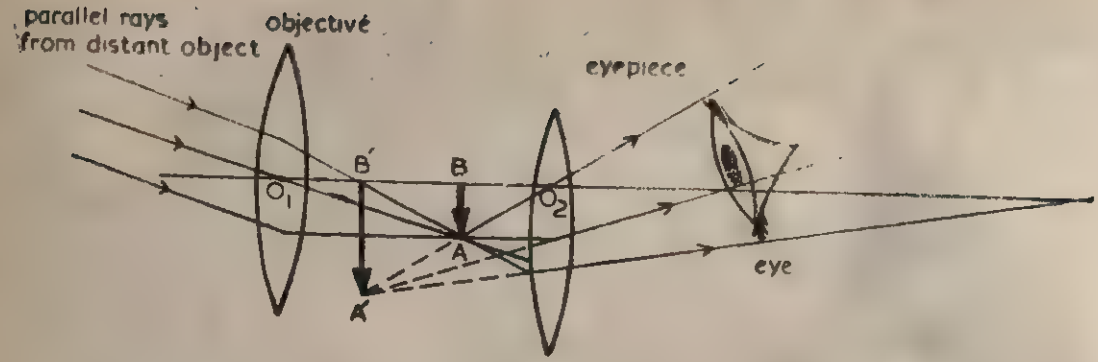


Fig. 4.39.

magnifying glass and produces a magnified virtual image of the first image (Fig. 4.39).

The motion of the moon and the planets was studied by using a telescope for the first time by *Galileo*, an Italian astronomer.

SUMMARY

1. Our chief source of light is the Sun. A large number of artificial sources of light are also in use.

2. Objects which give off their own light are called *luminous* objects. There are also non-luminous objects which do not produce any light.

3. Substances through which light can pass are called *transparent* and substances which allow only part of light to pass through are called *translucent*. Substances which do not allow the light to pass through them are called *opaque*.

4. A beam of light may be reflected, transmitted or absorbed.

5. There are two laws of reflection :

   (*i*) The angle of incidence is equal to the angle of reflection.

   (*ii*) The incident ray, the reflected ray and the normal at the point of incidence are all in the same plane.

6. The image formed by a plane mirror is virtual, erect and of the same size as the object but laterally inverted and is as far behind the mirror as the object is in front of it.

The Periscope used in submarines uses plane mirrors.

7. A concave mirror converges most rays while a convex mirror diverges most rays. Hence a concave mirror is sometimes called a converging mirror and a convex mirror is called a diverging mirror.

8. The concave mirror converges parallel rays or rays from a distant object to a point known as the *focus* of the mirror and forms a real, inverted and diminished image of the object there.

9. The convex mirror diverges rays from distant objects and forms a virtual, upright and diminished image behind the mirror at a point called its *focus.*

10. The distance between a curved mirror and its focus is called the *focal length* of the mirror.

11. When the object lies *within* the focus of a concave mirror, a virtual erect and enlarged image is formed behind the mirror.

12. Concave mirrors are used in torchlights, search lights and in special mirrors for shaving.

13. Convex mirrors are used in cars to enable the driver to see other cars approaching from behind.

14. There are two types of lenses. *Convex* or converging, *concave* or diverging.

15. The *focus* of a lens is the point at which rays coming from a distant object converge, or from which they seem to diverge, on passing through the lens. It is *real* for a *convex* lens but *virtual* for a *concave* lens. The distance between the focus of the lens and the lens is known as the *focal length* of the lens. This is different for different lenses and is a very important property of lenses.

16. As an object is moved towards a convex lens, a real, inverted image is formed which gets bigger and bigger until when the object is moved too near, an erect and enlarged virtual image is produced.

17. A concave lens gives a virtual, erect and diminished image of an object, no matter where the object is.

18. Lenses are used as magnifying glasses ; in cameras ; in spectacles, in microscopes ; and telescopes etc.

19. A lens also forms images in human eye.

20. The human eye can see distant and nearby objects by adjusting its focal length. It can have two main defects of vision—*short-sightedness* and *long-sightedness*—which can be corrected by wearing spectacles of suitable focal length.

21. The human eye is most sensitive to certain colours (green and yellow).

22. The structure of eyes of the back-boned animals is the same as ours. But insects have compound eyes.

QUESTIONS

1. Distinguish between :

   (*i*) Luminous and non-luminous objects. (Give three examples in each case).

   (*ii*) Transparent, translucent and opaque bodies. (Give three examples in each case).

   (*iii*) Regular and Irregular reflection of light.

2. (*a*) What is the chief source of light energy ?

   (*b*) What is the velocity of light in vacuum ? Is it the same for every medium ? What will be its value in (*i*) water and (*ii*) glass ?

   (*c*) How will you show by an experiment that light travels in straight lines ?

3. (*a*) What are the two things needed for vision ?

   (*b*) What is a pinhole camera ? Upon what principle does it work ? Explain how it forms an image of an object. What is the nature of the image formed by it ?

4. What is the difference between a mirror and a glass sheet ?

5. Why do some mirrors show distorted images ?

6. Are the images in curved mirrors of sizes different from the size of the object ?

7. Why do we hold a magnifying glass very near the object ?

8. We have two eyes but why do we see a single image ?

9. What is the difference between a telescope and a microscope ?

10. How can we focus distant and near objects with our eyes ?

11. How can we distinguish colours with our eyes ?

12. Why do some old people use two different types of glass (spectacles) ?

13. (*a*) Give the structure of the human eye.

    (*b*) What are the two main defects of vision and how are they corrected ?

14. (*a*) What is the principal focus of a :
(*i*) Concave mirror, (*ii*) Convex lens ?

(*b*) Draw diagrams showing how a
(*i*) Concave mirror (*ii*) Convex lens
can form (1) a real image (2) a virtual image.

15. (*a*) State three characteristics of the image formed by a camera.

(*b*) Compare the methods of focusing in the eye and in a lens camera.

(*c*) How is the amount of light passing through the lens changed in (*i*) the eye and (*ii*) a lens camera ?

16. (*a*) Explain how a person who is short-sighted fails to see distant objects clearly. Give diagrams.

(*b*) When the image of a distant object is focused in the vitreous humour of the eye, from what defect does the eye suffer ? Give a diagram.

(*c*) State the functions of the following parts of the eye :
(*i*) Cornea, (*ii*) Iris, (*iii*) Retina.

17. As a well-lit object is moved from any large distance towards a convex lens, describe the images of it produced by the lens with respect to the following :

(*a*) Where it is : whether on the same side of the lens as the object or on the other side ;
(*b*) Whether it is real or virtual ;
(*c*) Whether it is erect or inverted ;
(*d*) Whether it is enlarged, diminished or of the same size.

18. How much near to the book must you hold a convex lens if you want to use it as a magnifying glass ?

19. Strike off the words that do not apply in the following sentence :

An object placed anywhere in front of a concave lens will give an image which is real/virtual, erect/inverted, enlarged/diminished/the same size.

20. State the three things that may happen to a beam of light striking a body.

Which of the three is most likely to occur when a beam of light strikes the following :

(*a*) a plane mirror (*b*) a plane glass
(*c*) a polished table (*d*) coal tar

(*e*) a perfectly transparent body (*f*) a piece of diamond
(*g*) a black cloth (*h*) water
(*i*) stained glass.

21. (*a*) You can see your face in a polished top of a table but you cannot see it when it is not polished. Explain.
(*b*) State the laws of reflection of light. Draw a ray of light incident at 45° on a plane mirror. Draw the normal and the reflected ray. What is the angle through which the ray has been turned from its original direction ?
(*c*) Is the image produced by a plane mirror real or virtual, erect or inverted ; enlarged, the same size or smaller ?

22. (*a*) How can you tell the difference between concave and a convex mirror by looking at your face in each ?
(*b*) How can a concave mirror be used :
(*i*) to burn a piece of tissue paper ;
(*ii*) to send out a parallel beam of light ?
(*c*) Use diagrams to show why concave mirrors are called converging mirrors while convex mirrors are called diverging mirrors.

23. Describe the series of images formed by (*a*) a concave mirror, (*b*) a convex mirror, as the mirror is moved from a position near the face to about 100 cm. away.

24. What advantages, as a driver's mirror, does a convex mirror have over a plane mirror ?

25. What changes would you observe in your image as you moved nearer to :
(*i*) a plane mirror ; (*ii*) a concave mirror ;
and (*iii*) a convex mirror.

26. Define :
(*i*) Pole of a mirror
(*ii*) Centre of curvature of a mirror
(*iii*) Radius of curvature of a mirror
(*iv*) Principal focus of a mirror and a lens
(*v*) Focal length of a curved mirror and a lens.
Show them by means of diagrams.

27. Fill in the blanks with suitable words :

(*i*) ....surfaces act like mirrors.

(*ii*) We use.................as magnifying glasses. They are also used in.................and ....

(*iii*) If we throw a ball towards the plane mirror, the image of the ball appears to be moving.................the surface of the mirror.

(*iv*) The image formed by a convex mirror is.................and .... than the size of the object.

(*v*) The two main defects of vision are.................and ....

(*vi*) A.................also forms images in human eye.

(*vii*) The human eye is most sensitive to.................and ....colours.

(*viii*) The periscope used in.................uses ....mirrors.

VIBRATING BODIES AND SOUND

5.1. Production of Sound

A body produces sound only when it is set into vibration. For example, when the string of a sitar is plucked and set into vibration, it emits sound. Also, a drum produces sound when we set its leather membrane into vibration by striking it with a stick. Thus, sound is produced due to the vibrations in a body. *The number of vibrations made in unit time by a sounding body is known as its frequency.* It is measured in *Hertz.*

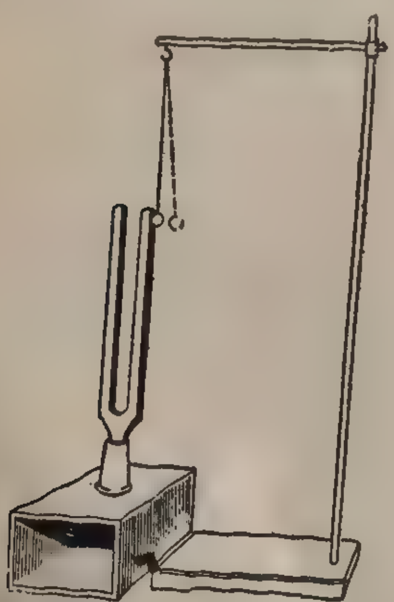


Fig. 5.1. Vibration in a sounding body

Activity 5.1.

Bring a suspending pith ball near a vibrating tuning fork. The pith ball will be thrown off with a jerk as shown in Fig. 5.1.

It will behave in the same manner if it is made to touch any other sounding body.

5.2. Propagation or Transmission of sound

Sound can be produced by a vibrating body but it will not be heard until it reaches the ear of the listener. Transmission of sound is as essential as its production. *Sound requires a material medium for its propagation.*

Activity 5.2.

Arrange an electric bell inside a glass bell jar on the receiver of vacuum pump.

Sound requires a medium for its propagation. Place a ticking clock upon a thick piece of rubber inside the bell jar.

Now start taking out air from the jar. As the air is taken out, the loudness of the ticking sound goes on decreasing until the sound becomes too faint to be audible even though

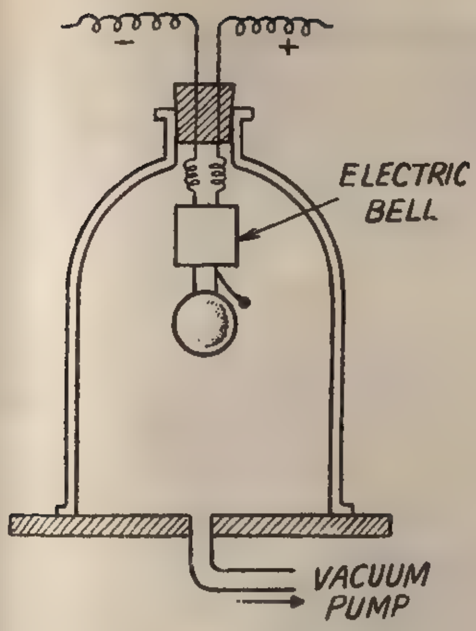


Fig. 5.2.

the clock is ticking as before.

If air is now allowed to enter the jar gradually, sound will go on becoming louder and until it attains its original intensity.

Sound cannot be propagated in the absence of the material medium of solid, liquid or gas.

The vibrations of a sounding body produces disturbance in the surrounding medium. The progressive transmission of a disturbance from point to point in a material medium or in space is termed as a *Wave.* The wave motion can occur only in a medium which possesses the properties of elasticity and inertia.

There are two important kinds of waves *transverse waves and longitudinal waves.*

A transverse wave is that wave in which particles of the medium vibrate about their mean positions in a direction at right angles to the direction of propagation of the wave.

In the case of strings, the sound travels in the form of transverse waves.

A longitudinal wave is that wave in which the particles of the medium vibrate about their mean positions along the line of propagation of the wave.

Sound travels in the form of a longitudinal waves in case of gaseous medium like air.

As a tuning fork vibrates, its prongs move alternatively inwards and outwards. Let a prong of a tuning fork move from A to A_1, then it compresses air in front of it as shown in the Fig. 5.3(*a*).

Due to elasticity, the compressed layer of air expands to regain its original volume and in so doing compresses the layer of air just adjacent to it. The compressed layer in turn compresses the next layer. In this way, the compression advances to the right from layer to layer.

When the prong moves from A_1 to A, it creates a partial vacuum behind it so that the layer of air in contact with it expands, thus producing rarefaction as shown in Fig. 5.4.

In order to regain its original size, the layer pulls the next layer, thus

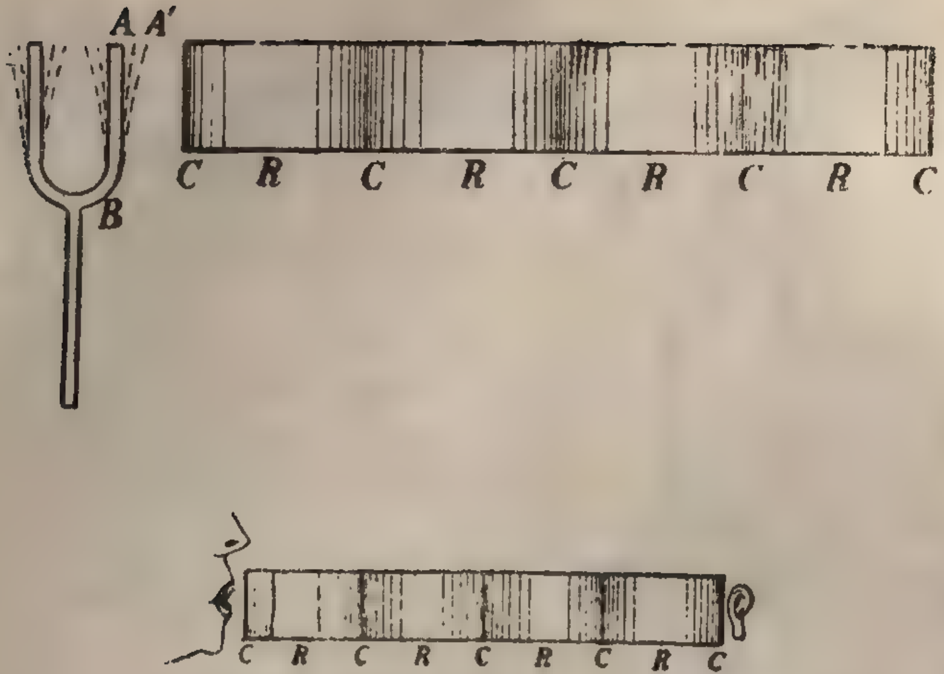


Fig. 5.3. (a) and (b). Propagation in a longitudinal wave

producing partial vacuum to the right. In this way a rarefaction moves to the right and follows the compression moving in front of it.

So *compressions* and *rarefactions* follow each other, thus forming a longitudinal wave.

5.3. Speed of sound

It is a common experience that thunder is heard several seconds after the flash of lightning is seen in the sky. This is because the speed of light is enormous in comparison to that of sound. The speed of sound in air is approximately 332 m/s at 0°C. The speed of sound increases by about 0·61 m/s for every 1°C rise in temperature of the air.

Solids and liquids can transmit sound faster than air because of their large elasticity.

5.4. Characteristics of sound (loudness and pitch)

The sound produced by various vibrating bodies (human voices, musical instruments etc.) are distinguished from each other by some of their characteristics such as *loudness* and *pitch*.

When we speak softly, our voice may not be heard after a little distance but if we speak with greater force, our voice may reach longer distances.

Sometimes, to make our voice louder, we make use of a microphone and loudspeaker.

A big drum produces a louder sound than a tabla with a small vibrating surface.

All string instruments are provided with an air box to make the sound louder.

Activity 5.3.

Place the base of a vibrating tuning fork on a bench. The sound will become louder. Why ?

Pitch or shrillness of sound depends upon the frequency of the sound wave. *The greater the frequency*, the *greater will be the pitch or shrillness.*

Activity 5.4.

Turn a bicycle upside down and spin the back wheel. Hold a piece of card on the spokes of the wheel. Observe the sound produced as the wheel is speeded up. You will notice that the pitch is higher when the wheel rotates fast.

Fig. 5.4. Pitch increases with increase in speed of rotation

The human ear responds normally to sound frequencies between 20 and 20,000 vibrations per second. The sound of the human voice is in the range of 60 to 13,000 vibrations per second.

Sound vibrations above 20,000 per second are called *ultrasonic*. Bats are known to generate and receive ultrasonic sound which helps them to find their way even in complete darkness. Dogs also respond to ultrasonic vibrations.

5.5. Reflection and absorption of sound

Let us perform an experiment to find out other properties of sound.

Keep a timepiece or a ticking toy at the bottom of a glass container, as shown in Fig. 5.5. We cannot hear

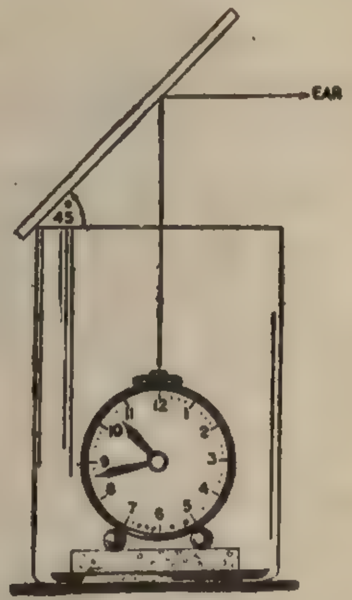


Fig. 5.5. Set-up of an experiment to observe reflection of sound

the sound very clearly. Hold a smooth wooden sheet as shown in the figure. Now we can hear the sound better. What is the reason ? The sound starts from the watch and reaches the sheet.

At the sheet, the direction of the sound waves changes and we hear the sound. This phenomenon is called *reflection* of sound.

Let us see how we listen to a person speaking in a room. When he speaks, the sound waves spread in the air in all directions. Some sound waves reach our ear directly and some strike the walls. The sound waves striking the walls get reflected and also reach our ears.

In the case of small size, all the reflected sound waves reach our ears at about the same time.

What happens when the sound waves reach our ears directly and also after reflection from a distant object ?

The human ear can listen two sounds separately only if they reach the ear after an interval of 1/15th of a second. This is a natural feature of the human ear. If we take the speed of second roughly as 330 metre per second, the distance travelled by a sound in 1/15th of a second would be 22 m. This means that we can hear the original and the reflected sounds if we are at a distance of 11 m. or more from the reflecting surface. This results in a very interesting phenomenon, called *echo*.

If you have not heard an echo, you can now try to hear one.

Can we now understand why is it difficult to hear sounds clearly in large rooms ?

The reflection of sound is used for measuring ocean depths. A short sound signal sent from the ship towards the bottom of the sea returns to the ship after being reflected from the bottom. Knowing the speed of sound in sea water and the required to cover the distance from the ship to the bottom and back, we can determine the depth of the ocean.

Let us now study whether sound is reflected equally from different materials ? We can study this by hearing the sound from one source or sounds being reflected from different bodies. Experimentally, it has been found that metallic sheets and plates of plywood are good reflectors of sound. On the other hand, clothing and porous materials, cork and thermocole are bad reflectors. They absorb most of the sounds striking them.

The walls, ceiling and floor of a good auditorium and cinema hall are covered by absorbing materials. So there is very little reflection of sound waves and the audience hear the sound coming only from its source but not the reflected sound.

5.6. Recording and reproduction of sound

Some of us are familiar with a gramophone. It is used to play a record (Fig. 5.6).

A record is a plastic disc with circular grooves on both its surfaces. In fact, there is only one continuous groove starting at one edge and running in smaller and smaller circles towards the centre of the disc. It is the track record of some sound (Fig. 5.7).

Fig. 5.6. A gramophone record—close look shows, its grooves.

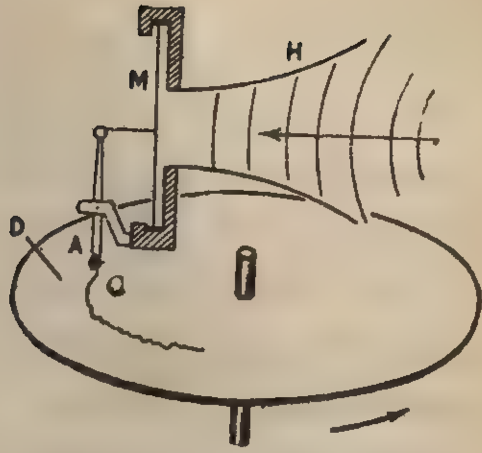


Fig. 5.7. A schematic view of recording on a gramophone record.

The membrane, M, which is made of a flexible material, is connected to the lever A, which has a cutter C at its tip. D is a metal disc coated with a sufficiently soft material.

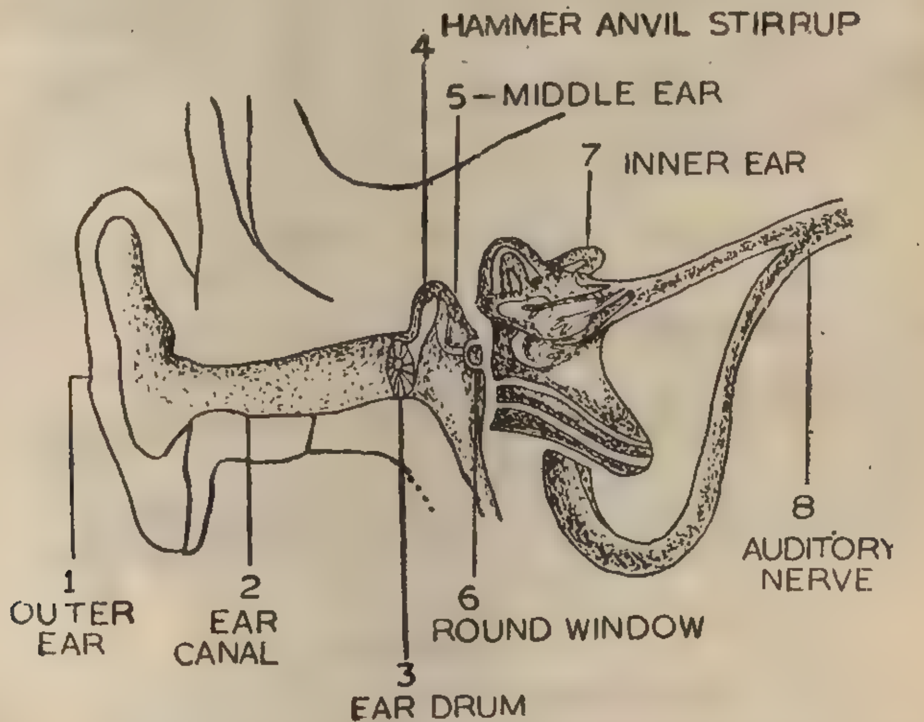


Fig. 5.8. A cut view of the human ear giving the inside details.

The sound waves from the source of sound pass through the horn H to the membrane M, which is thus made to vibrate with the frequency of the sound. The vibrations of the membrane are transmitted to the cutter C, where the vibrations are recorded in the form of a soundtrack in the soft material of the rotating disc. A metal copy is made from the disc which is then used for stamping gramophone discs.

A gramophone or radiogram (a device for sound reproduction) has a similar design. The main difference is that the cutter is replaced by a needle. The needle connected to the membrane is placed at the start of the soundtrack and the record is rotated. The needle sliding along the track sets the membrane vibrating ; this reproduces the sound recorded on the record.

Should we agree to call the gramophone a talking machine ?

5.7. The Human Ear

We can get an idea about our ear by looking at Fig. 5.8. We notice that sound travels through the outer ear and the ear canal to vibrate the small thin sheet (membrane), called ear drum. To understand the role of the middle ear and the inner ear we can take the help of the schematic diagram of the ear shown in Fig. 5.9.

A number of linked-up bones and canals lie between the ear drum and the nerves connected to the brain. All these parts carry the vibrations created by the sound in the ear drum to the auditory nerve. This nerve, in turn, take the message to the brain.

The tube connected to the throat is filled with air. It helps to regulate the air pressure on the ear drums and thus protects it from any damage due to very loud sounds.

Is nature's protection of the ear sufficient ?

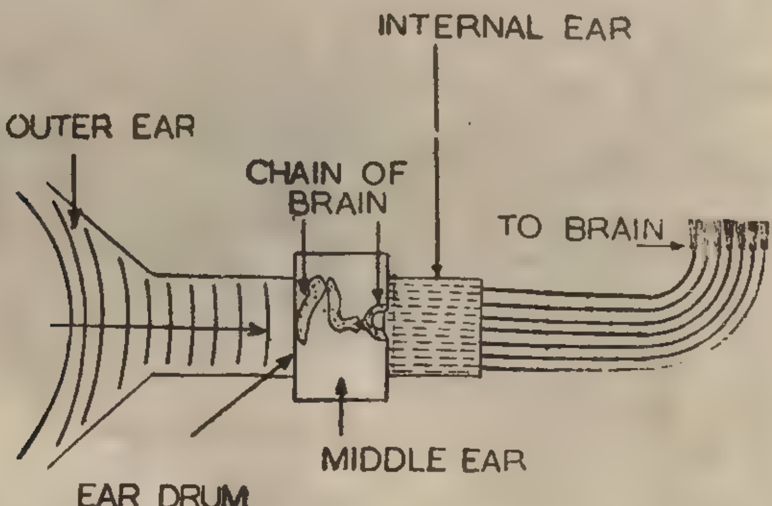


Fig. 5.9. A schematic diagram showing the action of sound on the human ear.

The human ear is a delicate organ. We must take special care of our ears. We should not put anything in the ear as it may damage the drum in it. We should not try to remove the wax-like material from the ear. Nature provides this wax to the ear to prevent foreign materials from going deep inside the ear. To prevent any damage to the middle ear, we should not blow the nose hard.

SUMMARY

1. A body produces sound only when it is in a state of vibration.

2. The number of vibrations made in unit time by a sounding body is known as its *frequency*. It is measured in *Hertz*.

3. Sound requires a material medium for its propagation.

4. The wave motion is a disturbance in a medium and it can occur only in a medium which possesses the properties of elasticity and inertia.

5. There are two important kinds of waves *Transverse waves* and *Longitudinal waves*.

6. Sound travels in the air at a speed of about 330 metres per second.

7. Solids and liquids can transmit sound faster than air because of their large elasticity.

8. The sound produced by various vibrating bodies are distinguished from each other by their characteristics such as *loudness* and *pitch*.

9. On striking same surfaces, sound waves get reflected. Some of the substances absorb sound when it strikes them.

10. Sometimes, we hear a sound directly separate from its reflected sound. This causes *echo*.

11. Sound can be recorded on plastic discs and reproduced by using a device like a gramophone.

12. The human ear can receive only those sounds which have a definite range of frequency.

13. Damage to the ear can make one deaf. The human ear is a delicate organ. It needs special care in spite of the protection provided by nature.

QUESTIONS

1. What is sound ? How is it produced ?

2. Give an experiment to demonstrate that a material medium is necessary for the propagation of sound.

3. How a transverse wave differs from a longitudinal wave ? Give an example of each wave.

4. In which of the three states of matter—solids, liquids and gases, do sound waves have their highest speed and why ?

5. Where do you think the sound will travel faster :

(i) near the sea.

(ii) on the top of a mountain.

Give reasons for your answers.

6. How does the sound produced by a Refree's whistle differ from that produced by a Scout's whistle ?

7. During a thunderstorm, the thunder is heard 1.25 S after noticing the flash of lightning. If the speed of sound is 350 m/s, calculate the distance at which the lightning has taken place.

8. The frequency of two sources of sound are 500 Hertz and 200 Hertz. Which of them produces a sound of high pitch ?

9. How can you raise the pitch of sound produced by a string instrument ?

10. What effect is produced in the air when the note produced by an instrument increases in loudness ?

11. Explain the difference in effect when a sound is produced, first in a heavily curtained room and then in a room which has plaster walls.

12. (i) What is meant by an echo ?

(ii) What are the conditions necessary for its production ?

(iii) Give two practical applications of the use of echoes.

13. Do all vibrating bodies produce sound ? Does sound travel in all directions ?

14. (a) Can sound be reflected ?

(b) How is sound recorded and reproduced ?

15. (a) How do we hear ?

(b) What is the internal structure of our ear ? Should we take care of our ears ? How ?

16. Complete the following statements :

(a) The two important kinds of waves are.................and...............

(b) The frequency of a vibrating body is measured in......................

(c) Musical instruments produce......................

(d) The sound produced by the humming of a bee is.................... than the roaring of a lion, though the latter is much..................

(e) On striking some surfaces, sound waves get...............and some of the substances......................sound when it strikes them.

(f) Solids and liquids can transmit sound.....................than air.

17. Match the words given in column A with those of column B :

Column A	*Column B*
(i) The speed of light is	(i) 20 and 20,000 vibrations per second.
(ii) Sound of higher frequency is said to have	(ii) ultrasonics.
(iii) Human ear responds to	(iii) 60 and 13,000 vibrations per second.
(iv) Human voice is in the range	(iv) good reflectors of sound.
(v) Sound vibrations above 20,000 vibrations per second are	(v) bad reflectors of sound.
(vi) Plywood and metallic sheets are	(vi) higher pitch.
(vii) Cork and thermocole are	(vii) 100.000 km/sec.

6

ELECTRIC CHARGE AT REST AND EFFECTS OF ELECTRICITY

6.1. Historical Background

It is impossible to determine when electricity was first discovered. Records show that as early as 600 B.C. the attractive properties of amber (a yellow stone) were known. Thales of Miletus (640—546 B.C.), one of the "Seven wise men" of ancient Greece, is credited with having observed the attraction of amber. He found that, after rubbing a piece of amber with wood the amber would mysteriously attract certain materials like bits of papers, wood and feather. This characteristic phenomenon caused confusion until 1600 A.D. when William Gilbert gave us the first theory about electricity. Gilbert is justly called the father of electricity. He is also credited with naming it as electricity, the word electricity being derived from the Greek word for amber, "elektron". Amber was used by these people, even as it is now, for ornamental purposes.

6.2. Electrification of bodies by Friction

It is now a well established fact that all bodies when rubbed together acquire the attracting power and that amber is just one of a number of substances that show this property most strongly.

Have you ever noticed that when you take off a terylene shirt there is a clicking noise and that when the shirt is off it will attract bits of paper ? A similar effect can be obtained by rubbing a fountain pen on your sleeve ; it will then pick up bits of paper. A shock is sometimes experienced when you touch the door handle of an automobile after sliding over the plastic covered seat. The slight cracking sound that is heard when dry hair is brushed and the tendency of thin sheets of paper to resist separation are some of the common examples of electrification of bodies by friction.

The agency which imparts this attracting power to a substance by the process of rubbing is given the name static electricity. It is called static as it does not move from one point to another in a body in which it is produced. The bodies in such a state are said to be *electrified* or *charged*.

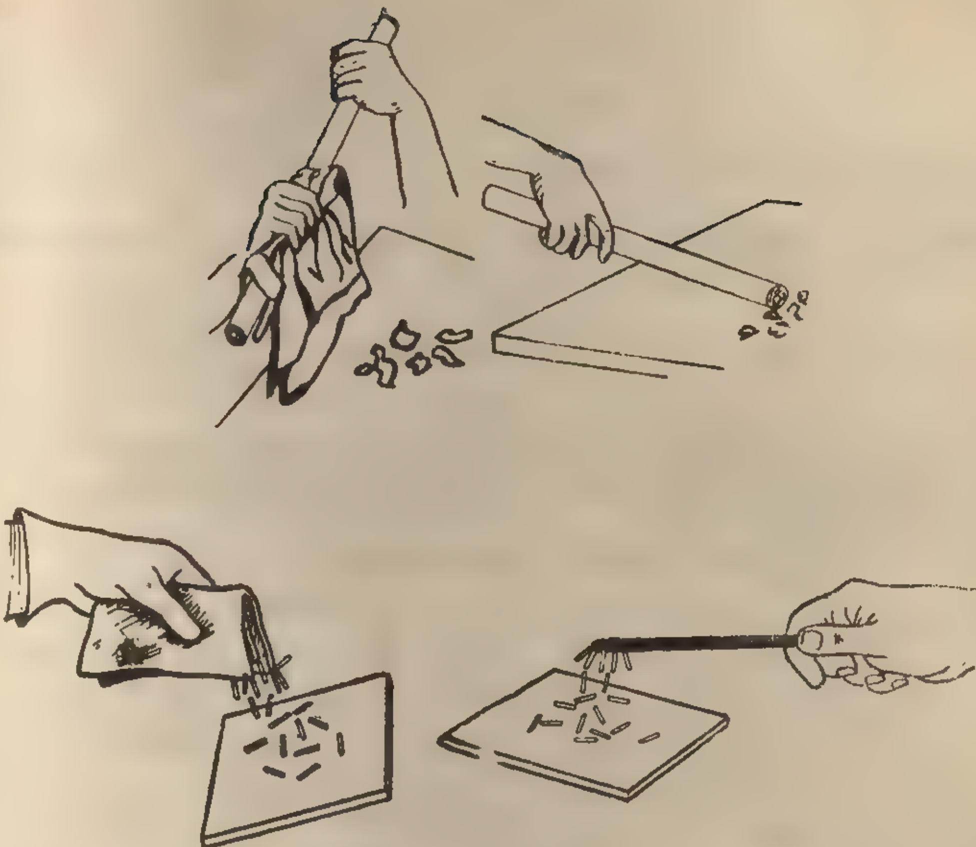


Fig. 6.1.

Activity 6.1.

Take a glass rod and bring it near the pieces of paper. What happens ?

Rub the glass rod briskly with a piece of silk. What happens now if you bring the rubbed glass rod near the pieces of paper ?

To get good results be sure your hands are dry and use rubber gloves.

Will the silk cloth also attract small pieces of paper after the glass rod is rubbed with it ?

What does this activity prove ?

6.3. Two Kinds of Electric Charges (Interaction of charged bodies) :

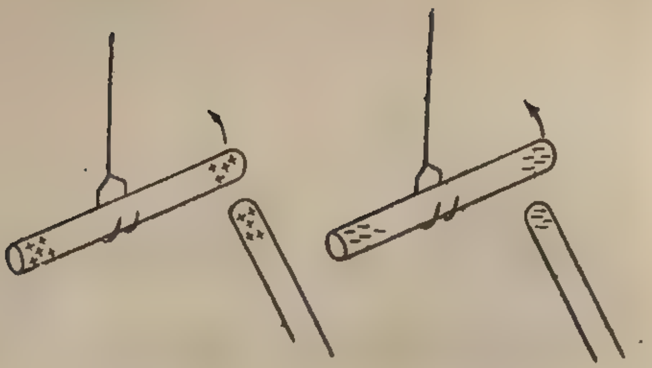
Activity 6.2.

Suspend rods of glass and ebonite in small wire stirrups as shown in Fig. 6.2 on next page.

Rub the suspended glass rod with a silk cloth. Bring the two rods near each other, but without letting them touch each other. What do you observe ?

Now rub a second glass rod with a silk cloth and bring it near the suspended glass rod, then near suspended ebonite rod. Note what happens ?

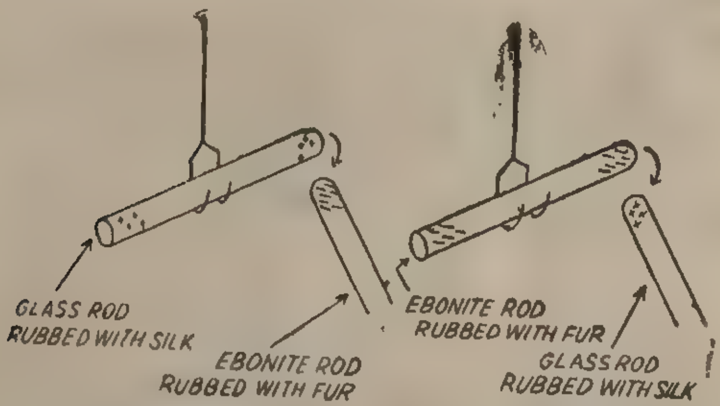
Next rub the suspended ebonite rod and the free ebonite rod with fur



(a) (a) Two glass rods rubbed with silk ; the suspended rod moves away when the other rod is brought near it.

(b) (b) Two ebonite rods rubbed with fur ; the suspended rod moves away when the other rod is brought near it.

Fig. 6.2. (a, b). Repulsion between charges of the same kind.



(c) (c) The suspended glass rod moves closer to the ebonite rod.

(d) (d) The suspended ebonite rod moves closer to the glass rod.

Fig. 6.2. (c, d). Attraction betweeen charges of opposite kind.

or flannel. Bring the free ebonite rod near the suspended ebonite rod and then near the suspended glass rod. Observe what happens.

How do the different free rods act on the different suspended rods ?

From these tests, what do you deduce about the types of electric charges ?

These tests show that there are two kinds of electrification or electric charge. When an ebonite rod, rubbed with fur, is brought near another rubbed ebonite rod which is suspended so that it is free to move, it is found that the two rods repel one another.

Similarly, two dry glass rods,

rubbed with silk, are found to repel each other. On the other hand, a glass rod, rubbed with silk, tends to attract a rubbed ebonite rod. The charge produced on the ebonite rod, therefore, must differ from that on the glass rod.

A similar series of experiments using other materials, such as sealing wax, polystyrene etc., confirm the fact that *there are two, and only two different kinds of charge.*

Benjamin Franklin gave the name positive charge to that acquired by the glass rod rubbed with silk and the charge on the rubbed ebonite rod was named negative.

The nature of electricity developed on a particular body depends upon the nature of the material of the rubbing substance. For instance, glass when rubbed with silk acquires positive electricity, but when rubbed with fur acquires negative electricity.

Positive charge is denoted by a *plus* (+) *sign* and negative charge by a *minus* (—) *sign.*

Not only do the above experiments indicate the existence of two kinds of electrification, but they also demonstrate a rule concerning the action of one kind of charge on another. The rule, can, therefore, be stated that "*Like charges repel and unlike charges attract.*"

6.4. Transfer of Charge due to Contact

A body need not necessarily be rubbed with another to be charged. It is quite sufficient, for instance, to touch it with some other charged body.

Activity 6.3.

Take a small pith ball (pithy core of a corn cob), coat it with a metallic paint and suspend it by a silk thread as shown in Fig. 6.3.

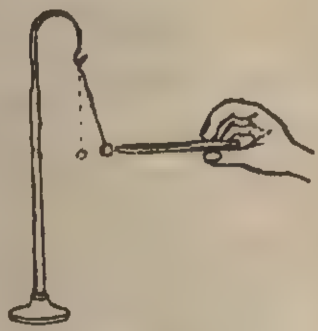


Fig. 6.3.

Take an ebonite rod and charge it negatively by rubbing it with flannel or fur. Hold the end of the charged rod near the pith ball, but without letting it touch the ball. What do you observe ?

Now allow the pith ball to come in contact with the charged rod. Note what happens.

When the negatively charged ebonite rod is brought near the pith ball, the pith ball is attracted to the rod and then having touched it, it immediately rebounds and is then repelled by the rod. We may reasonably assume that some of the negative charge has been transferred to the pith ball so that both the rod and

the ball are now similarly charged.

This supposition can be proved by bringing near to the charged pith ball, a positively charged glass rod. The pith ball is attracted rather than repelled.

So from this activity we can draw the conclusion that a body can be charged due to contact with another charged body and it receives a charge similar to the charge of the body with which it was in contact.

A strip of brass or an aluminium sheet (about 8 cm. by 1 cm.) is bent as illustrated in Fig. 6.4. and fixed over a glass rod held in a retort stand and boss. To one side of the brass strips, a thin aluminium leaf is attached. The aluminium leaf can be cut with a razor blade into a strip about 7 cm. by 1 cm.

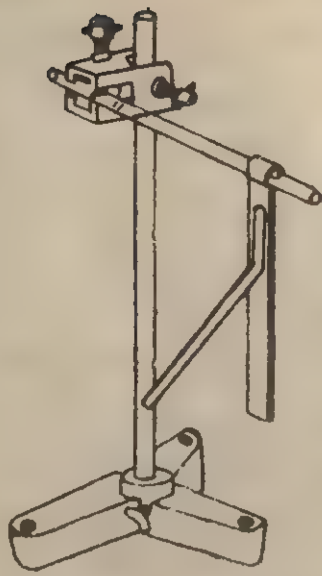


Fig. 6.4.

If the brass strip is touched across its edge which is on the glass rod with a charged ebonite rod, part of the negative charge will pass through the brass strip to the aluminium leaf with the result that the leaf will rise. Why does the leaf rise ?

6.5. Electroscope

With this device (Fig. 6.4) you will be able to detect and identify charges. The operation of an *electroscope*, a device used for detecting electrical charge of bodies, is based on the above-mentioned physical phenomenon.

In its simplest form (Fig. 6.5), electroscope consists of a glass bell-jar B without base. The bell-jar rests on a circular wooden base. The mouth of the jar is fitted with an ebonite stopper (P) filled with sulphur or some other non-conducting material. Through this stopper passes a brass rod C having a circular brass disc M at one end and two thin gold leaves G,G at the other end as shown. Two tin foil strips TT begin from the level of the gold leaves and pass down

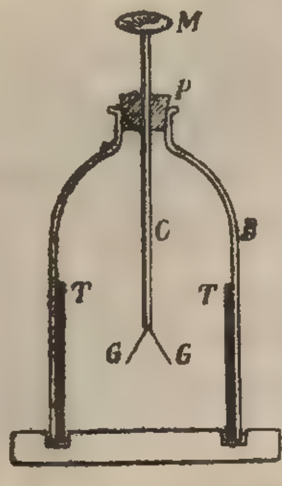


Fig. 6.5. Gold-leaf Electroscope

to the base which is also covered with a tin foil sheet. The strips are then connected to the earth. This arrangement makes the instrument more sensitive. In order to keep the air inside the electroscope dry, a small vessel containing calcium chloride or a pumice stone soaked in strong sulphuric acid is placed inside the instrument. This avoids the leakage of charge from the gold leaves.

Fig. 6.6 shows a different design of the electroscope, in which there is a metallic knob at the upper end of a metal stem. A thin strip of gold leaf is fastened to the side of the stem. The leaves are protected by a metal case with glass observation windows. The metal stem is carefully insulated from the metal case.

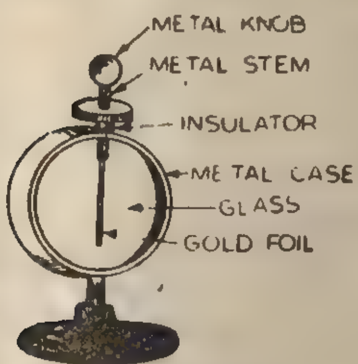


Fig. 6.6. Electroscope

To charge the gold-leaf electroscope positively, rub a glass rod with silk and touch it on to the disc of the electroscope. A positive charge is conducted to the leaves. Since both the leaves are charged with the same kind of electricity, these repel each other and diverge. The divergence of the leaves indicates the presence of an electric charge. This process of charging the electroscope is called charging by conduction.

To charge the gold-leaf electroscope negatively, touch the disc with an ebonite rod rubbed with fur.

If the divergence of leaves is very large, these will touch the tin foils which conduct away the charge to the earth and the leaves then collapse.

6.6. Conductors and Insulators

Not everything allows electric charge to pass through it easily. Some materials allow electric charge to pass through them easily, others do not. The materials that allow electricity to flow through them easily are known as *conductors*. Those through which it is difficult for electric charge to flow are known as *insulators* or non-conductors.

Let us test and see which are the materials that are conductors and which are the materials that are insulators.

Activity 6.4.

Suspend a small brass ball by a silk thread and then join the ball to the brass knob of a gold-leaf electroscope by means of a copper wire as shown in Fig. 6.7. Charge the ebonite rod and touch it to the brass ball. What happens to the leaves of the electroscope ?

Now substitute a silk thread for copper wire. Charge the ebonite rod

again and touch it to the brass ball. What happens now ?

In the first case using copper wire, the leaves of the electroscope diverge. Apparently the charge on the brass ball is transferred to the electroscope by the copper wire. In the second case when the silk thread is substituted for the copper wire, the leaves of the electroscope do not diverge because the charge has not been transferred to the electroscope by the silk.

Repeat the experiment using a number of substances. Separate them into conductors and insulators.

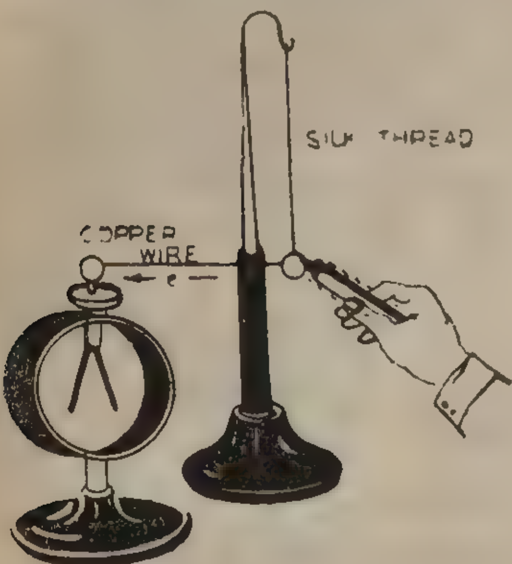


Fig. 6.7

Most metals are good conductors. At normal temperatures, silver is the best conductor ; copper and aluminium follow in that order. Graphite, the human body and certain solutions are good conductors also.

Good insulators are silk, paraffin wax, glass, dry air, mica, hard rubber, bakelite and many plastics ; porcelain insulators for power line ; etc.

Conductivity and insulation of a certain material is a relative term. There is no substance which is a perfect insulator. There are certain substances whose property of carrying charges lies between conductors and insulators. Such substances are cotton, wood, paper, etc.

Telegraph and telephone wires are made of hard-drawn copper as they are good conductors. These wires are placed on inverted cups of porcelain which are insulators and thus avoid the leakage of charge through poles.

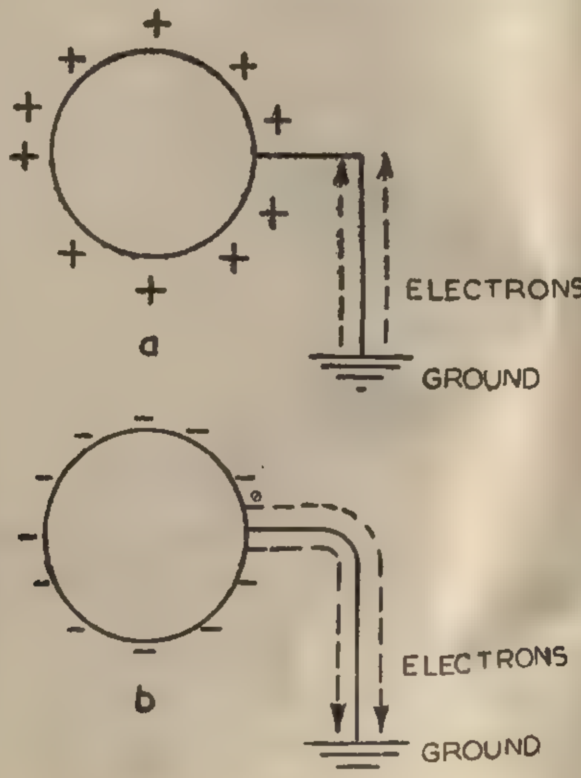


Fig. 6.8.

Copper wire in electrical wiring at home is used as it is a good conductor.

A good conductor contains a large number of free electrons and if such a material is brought into contact with a charged body, a transfer of charge takes place. An insulator has few free electrons because even the outermost electrons are rather firmly held within the atom structure. Thus, the transfer of charge through an insulator is usually negligible.

6.7. Electrical Phenomena in the Atmosphere

The occurrence of lightning and thunderstorm has been known to man for a very long time. These natural phenomena were the cause of much speculation about their origin and nature. In 1748, Nolled, a French scientist, noted a number of similarities between electricity and lightning and expressed his views that they were different aspects of the same phenomena. It was left to Benjamin Franklin who, in 1750, established the complete identity of lightning flash and the electric spark. He devised an experiment in which he allowed a spark discharge to pass between two highly charged plates. He found that this discharge resembled the lightning and its path was zig-zag. He killed a hen and struck a pigeon blind by an electric discharge just as the lightning flash kills men and strikes them blind in nature. Other points of similarity that Franklin listed between them were at both gave light, the colour of their light is similar, their motion is very swift and that the crackling noise is produced in both cases. The final proof was given by him in 1752 when he collected electricity from a cloud. During a thunderstorm, he flew a kite which had projecting from it a sharp pointed wire in a field near Philadelphia. The kite was flown with an ordinary string and to the other end of the string was attached a key separated from the observer by a silk thread. The silk thread was fixed to a tree. As soon as a charged cloud came over the kite and thread made wet by the rain, electricity flowed from the thread to the key. When he put his hand near the key, a spark jumped to his fingers.

Franklin showed that clouds and the Earth store electricity. The lightning was the discharging.

When the thunder clouds with unlike charges approach each other, a powerful electric field is set up between them. Under its effect the electrons start moving from the negatively charged thundercloud across the air, which becomes heated by the electric current and becomes a rather good conductor. As a result a lightning flash occurs between the two charged clouds. The discharge lasts for about $\frac{1}{10000}$th of a second. Rapid and energetic expansion of the heated layers of air produces sound waves which we hear as thunder

Fig. 6.9.

Fig. 6.10.

claps. Lightning and thunder occur simultaneously but we usually hear the clap of thunder after we have seen the flash of lightning. This is due to the fact that sound in the air propagates with a speed of 330 m/sec and light propagates with a speed of 300,000,000 m/sec.

An electric discharge lightning can occur not only between two clouds but also between a charged cloud and the Earth.

When, for instance, a negatively charged cloud comes sufficiently close to the Earth, it induces, particularly on high ground, a powerful positive charge directly underneath. As the cloud moves, the area of positive charge underneath it moves. More often a stroke of lightning takes place between the cloud and the Earth. As is clear from the Fig. 6.10 a lightning lining can be many kilometres long.

6.8. Lightning Conductors

Lightning is always dangerous and unpredictable. It can split a tree and very often it is the cause of fires if it strikes, a building.

A lightning conductor is a protective device fitted to tall buildings and to other installations. It consists of three essential parts :

(*i*) A rod made of copper or galvanised iron raised above the highest point of the building. It ends into a large number of sharp points.

(*ii*) A conductor connecting the rod with the ground. It is generally a copper or an iron strip.

(*iii*) The earth connection. The lower end of the strip carries a big metal plate which is burried deep into the moist part of the earth.

The action of the lightning conductor is explained in two ways ;-

During a thunderstorm, a charged cloud passes above the points of the lightning conductor. If the cloud is negatively charged, it induces positive charges on its upper end (Fig. 6.11). These positive charges become so tightly packed that they ionize the air surrounding them. Repelled by the positive charges left behind in the conductor and attracted by the negative charges in the cloud, air molecules are free to move up towards the cloud. The charged molecules form an 'invisible' wind which allows charge to leak away from the building or Earth. If the wind reaches the cloud, it neutralizes the negative charge there and stops it coming down from the cloud in a flash of lightning.

If a discharge actually takes place, the lightning conductor provides an easy passage to the charge from the cloud to the Earth. The building is thus saved from the destructive effects of this lightning.

6.9. Electric Potential

When we raise a body from the ground to certain height we do a certain amount of work on the body.

Fig. 6.11. Lightning Conductor

This increases its potential energy. Therefore a point at a higher level means a point of greater potential energy or a higher gravitational potential. Now we know that a body if left to itself falls down from a point of greater potential energy or a higher gravitational potential to a point of lower gravitational potential. Similar is the case with electricity. Suppose we have two insulated conductors A and B, charged positively. If we place them in contact or connect them by a wire, charge will flow from one conductor to the other. The direction of flow of charge depends upon the electric condition of the two conductors.

The electric condition of a conductor which determines the flow of electric charge from it to another conductor placed in contact is known as its **electric potential.**

If the positive charge flows from conductor A to conductor B, then A is at a higher potential than B. The flow of charge continues so long as the potential of A remains higher than that of B and stops as soon as the potential of the two conductors becomes the same.

Electric potential is analogous to level in the case of water, to temperature in the case of heat and to pressure in the case of gases.

Activity 6.5.

Take two cylindrical vessels containing water (Fig. 6.12) connected by a tube provided with a stop-cock.

Fig. 6.12.

Open the stop-cock. What do you observe ? What happens to the flow of water after some time ?

On opening the stop-cock, you will observe that water flows from the vessel in which the surface of water has higher level than the other even though the quantity of water in the former vessel may be less than that in the latter. There will be no flow if the levels are the same.

Activity 6.6.

Take a small copper piece and heat it red hot. Place it in a bucket-full of water at room temperature containing a thermometer. What do you observe ? What happens to the flow of heat after some time ?

You will observe that heat will flow from the copper piece to the water, though the quantity of heat in the water may be much greater than that in the copper piece. Heat flows from the copper piece to the water only because the former is at a higher temperature. There will be no flow of heat from either of them to the other if their temperatures are the same.

Since temperature is the degree of hotness of a body so electric potential

may also be defined as *the degree of electrification of a charged body.*

Just as the height of a place is measured with respect to sea level which is taken as zero or a standard level (as its capacity for water is so huge that any addition or removal of a small quantity of water does not affect its level appreciably) the potential of a conductor is measured with respect to that of the earth which is taken at *zero potential.* Earth is a good conductor of electricity and has a huge capacity for electric charge and any addition or removal of a small charge would not alter its potential appreciably.

The potential of a positively charged body is above the potential of the earth and potential of a negatively charged body is below that of the earth. Thus a positively charged conductor has a positive potential as the positive charge flows from it to the earth. A negatively charged conductor has a negative potential as positive charge flows from the earth to the conductor (the electron flow would be from the conductor to the earth). **An earth-connected conductor has zero potential.**

6.10. Structure of an Atom :

All substances consist of atoms. An atom is so small that it cannot be seen. An atom contains a central core with almost all the mass of the atom concentrated there. This core is called the *nucleus* and it is always *positively* charged. There are *negatively* charged minute particles that revovle in orbits round the

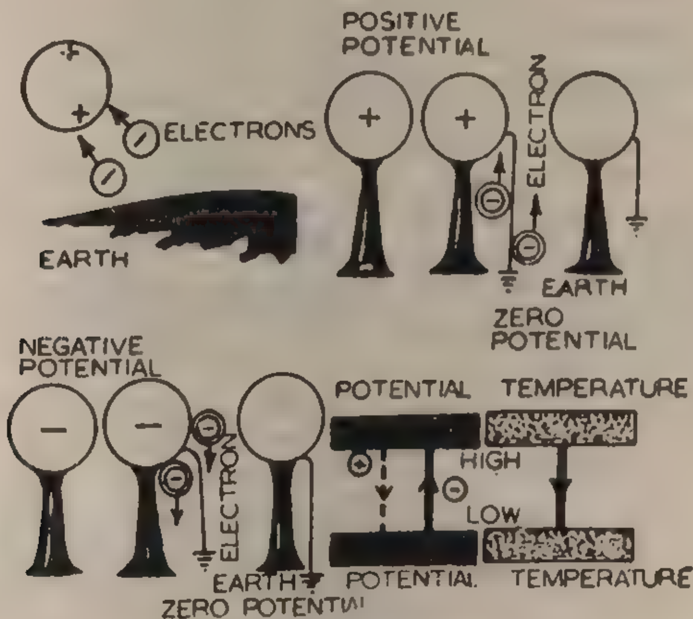


Fig. 6.13

nucleus. These particles are called **electrons.** Nucleus is made up of two particles "**protons**", *positively* charged particles and "**neutrons**", particles having *no charge* at all and mass slightly greater than that of protons. There are as many revolving electrons as are the number of protons in the nucleus and hence the atom remains electrically neutral. For example a hydrogen atom consists of one proton in the nucleus and one electron revolving round the nucleus (Fig. 6.14).

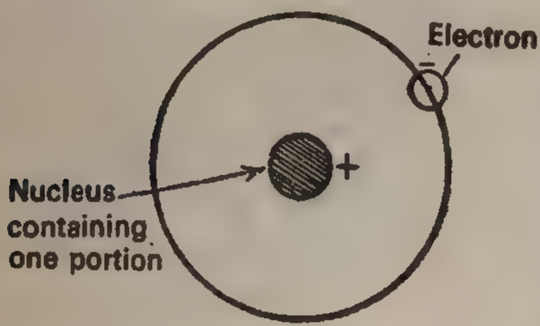


Fig. 6.14. Hydrogen atom

6.11 What is an Electric Current ?

We have learnt about the transfer of charge, that is, when two points at a different electrical potential are joined by a conductor, electrons flow along the conductor from the point at the low potential to the point at the higher potential (positive charge flows from the one at a higher potential to the other at a lower potential) until the potential at both points becomes the same.

Such a flow of electric charge is called an electric current.

Thus an electric current flows when there is an *electric potential difference.*

To keep an electric current flowing to a conductor, it is obviously necessary *to maintain the potential difference between its ends*, that is, to maintain a difference in electrical energy level between the ends. This, of course, requires the expenditure of some other form of energy. Taking again the hydrostatic analogy (Fig. 6.13), if a continuous current of water is to be obtained between the two vessels, their difference of level must be maintained by pumping back water from the vessel in which it is at a lower level to the one in which its level is higher, at the same rate at which it flows from the latter to the former. And this obviously entails an expenditure of energy (mechanical). So also, if a continuous flow of electric current is to be maintained between the two conductors some device must be found to transfer charge or electricity from the conductor at the lower potential to that at the higher potential, at the same rate at which it flows from the latter to the former.

6.12. Sources of Electric Current

(1) Simple Voltaic Cell

Luigi Galvani (1737-1798), a professor of anatomy at the University of Bologna in Italy, made a discovery which led to the development of the first primary cell. He observed that frog legs, freshly dissected and suspended on copper hooks twitched when touched with an iron railing

just below the legs. Galvani believed that the twitching was due to 'animal electricity' in the frog's leg.

Volta, who was a professor of Physics at the University of Pavia at this time investigated Galvani's observation. He discovered the correct explanation for the strange behaviour of the frog's legs : two dissimilar metals immersed in a conducting fluid cause a chemical reaction capable of producing an electric current. As a consequence of his investigations, Volta invented the first primary cell, now called the Simple Voltaic Cell.

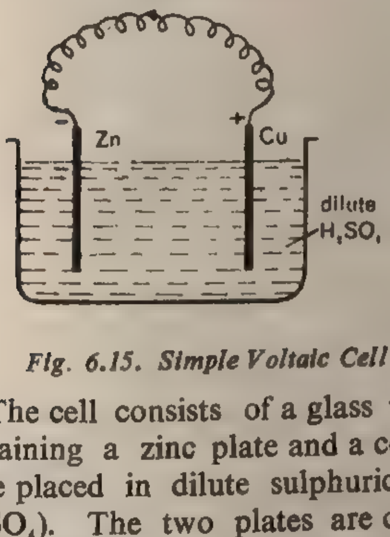


Fig. 6.15. Simple Voltaic Cell

The cell consists of a glass vessel containing a zinc plate and a copper plate placed in dilute sulphuric acid (H_2SO_4). The two plates are called the electrodes and the liquid in which they are placed is known as the electrolyte.

There is no chemical action between copper and dilute sulphuric acid. If we now connect the two plates by a piece of copper wire through a small torch bulb (Fig. 6.15), the bulb begins to glow. This shows that an electric current is flowing through the bulb from the cell. At the same time bubbles of hydrogen gas are seen to collect near the copper plate showing that a chemical action is taking place. Interacting with the acid, the zinc plate becomes more negatively charged than the copper plate. An electric field is set up around the charged plates which sets up and maintains an electric potential difference between the plates and hence electrons begin to move from zinc plates at lower potential to copper plate at a higher potential through the wire connecting them. Positive electricity flows from copper to zinc through the copper wire outside the cell. The copper plate from which the current starts is called the *positive pole* and the zinc plate through which the current enters the cell is called the *negative pole* of the cell. The direction of the current in the outer circuit is from the positive pole to the negative pole (conventional current) *i.e.*, from copper to zinc, and within the cell the direction is from zinc to copper. The true flow of an electric current consists of the movement of electrons in the opposite direction (electron cerrent) *i.e.*, from zinc to copper (See Fig. 6.15).

The source of the energy of the cell is the action of the sulphuric acid on the zinc which is gradually consumed.

The zinc may be regarded as the fuel of the cell just as coal and petrol are consumed in railway and car engines.

The Dry Cell (*Torch light*) :

The dry cell used in torch light is the only primary cell in common use It is in fact a Leclanche cell in its miniature form (Fig. 6.16).

The cathode (negative electrode) is a zinc container and the positive electrode a carbon rod. The carbon rod is surrounded with a mixture of manganese dioxide (the depolariser) and powdered carbon in a muslin bag. The electrolyte in the dry cell is a moist paste of ammonium chloride containing some zinc chloride, saw dust and plaster of paris.

The zinc container is placed in a leakproof cover and the top is sealed with tar.

The chief advantage of the cell is that it is portable ; its disadvantage is that it deteriorates when left unused on the shelf.

One cell is insufficient for supplying enough power to the bulb of a pocket torch. If two or more cells are connected together, they form what is called a battery. The common flashlight contains three dry cells connected

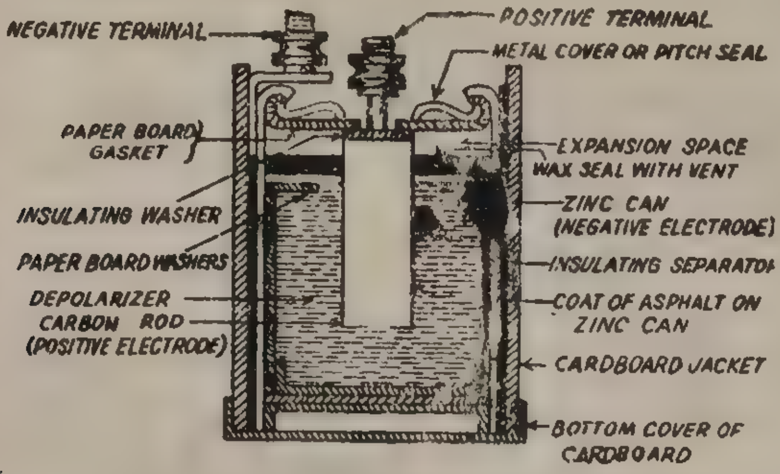


Fig. 6.16. (a) Dry cell (For General Use).

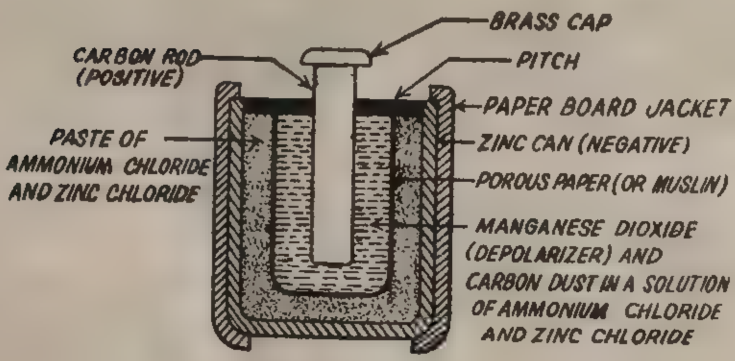


Fig. 6.16 (b) Dry Cell for Torch

in series. In series connections, the positive electrode of one cell is connected to the negative terminal of the next *i.e.*, the carbon rod of the first cell is connected to the zinc container of the second and so on. The purpose of connecting two or more cells in series is to obtain a higher potential difference than that available with one cell alone. The potential difference between the extreme end terminals (Fig. 6.17) of the battery is

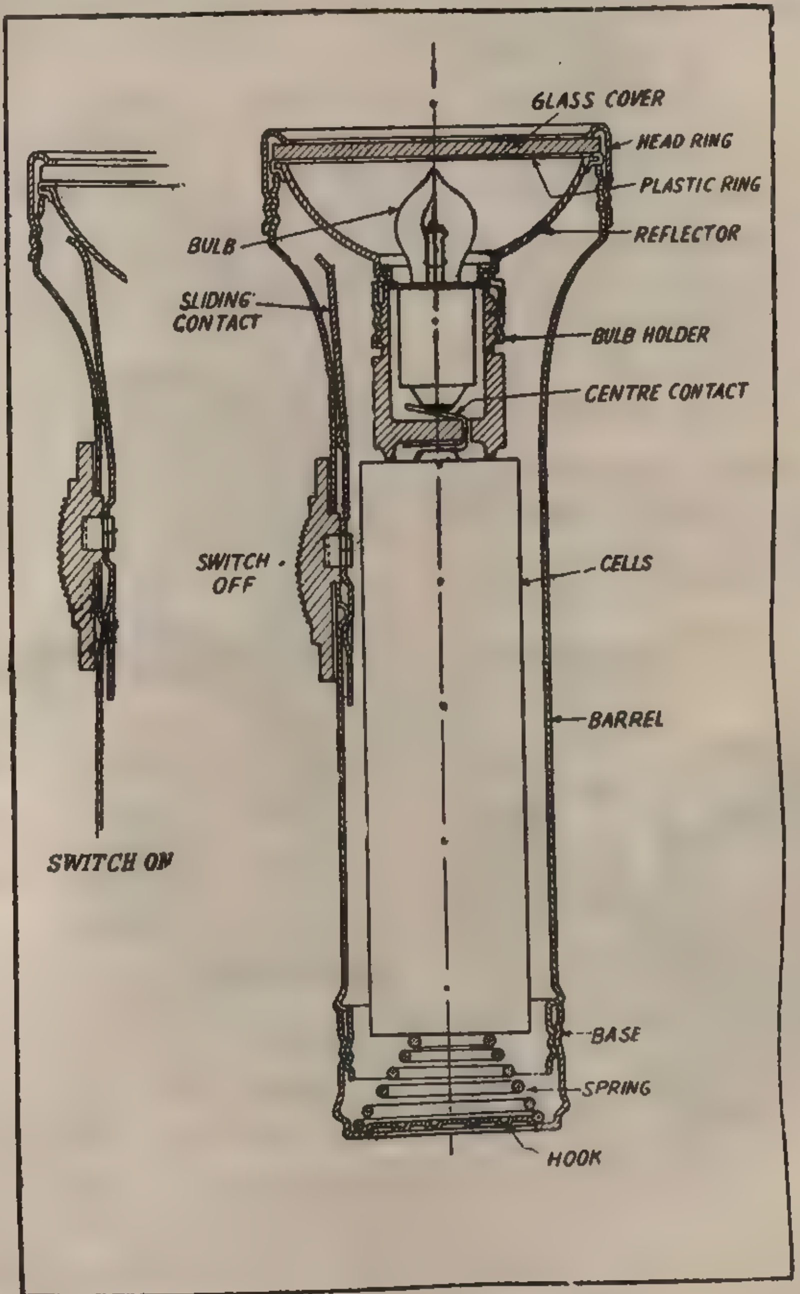


Fig. 6.17. The Torch (dry cell type)

equal to the sum of these for the individual cells.

(2) The storage batteries :

When the electrical energy contained in a battery composed of dry cells has been exhausted, it is thrown away. A storage battery on the other hand, is composed of what are called *wet cells*. When the energy of such a battery is exhausted it can be *recharged*. Storage batteries provide a far more convenient source of electric current. Storage cells of three types are now in general use, the lead-acid cell, the Edison cell and the nickel-cadmium cell. The lead-acid cell is by far the most widely used type.

The simple storage lead-acid battery or accumulator consists of two lead plates immersed in a dilute sulphuric acid solution contained in a glass vessel. If we connect a small electric bulb across the two plates, we will find that it does not glow.

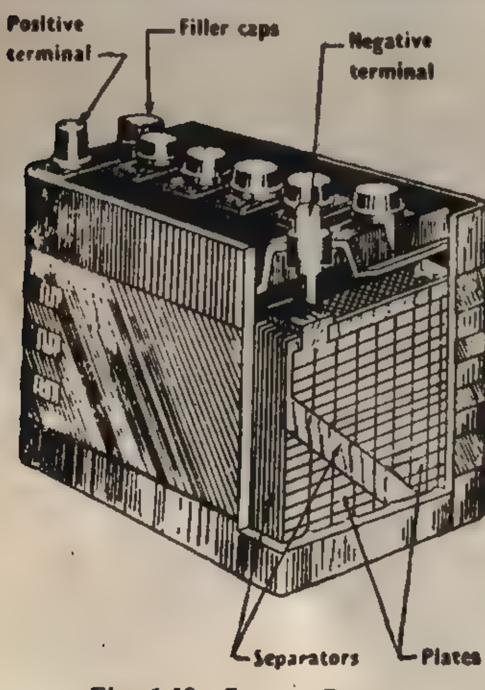


Fig. 6.18. Storage Battery

Such a battery has to be charged before it can supply electric current. For this purpose an electric current from another source is passed through it.

The use of storage batteries is wide and varied. They are used for illuminating railway carriages, for supplying power to head lights of motor cars and to start its engine. Powerful storage batteries are used to propel submarines under water. Radio transmitters and scientific apparatus of the earth's artificial satellites are powered with the help of storage batteries.

Light a bulb using one dry cell. Add another dry cell to the circuit and

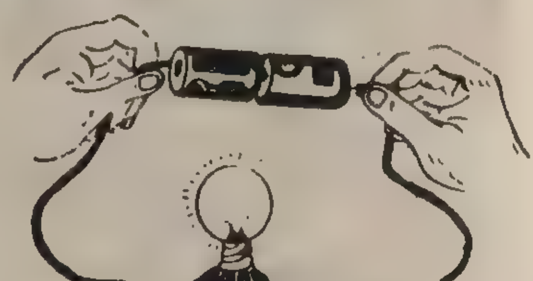


Fig. 6.19.

connect the apparatus as shown in Fig. 6.19. What happens to the bulb ? Notice the brightness of the bulb. Is it brighter than the circuit with a single cell ? Can you explain why ?

Turn over one of the dry cells and join the two cells in opposite directions. Does the bulb light up ?

From the above activity you have

observed that if you have two batteries (dry cells) connected in the proper way then the drive or push becomes stronger. Therefore there is more electricity.

Generators or Dynamos :

A dynamo is a machine used for generating electric current by mechanical means or a machine in which mechanical energy is changed into electrical energy.

When the electric current produced by a dynamo changes its direction of flow continuously and periodically in a circuit several times (about 50 times in general) in a second, the current is known as an alternating current (A.C.) and the machine that produces it is known as alternating current dynamo or A.C. Dynamo or Generator. When the electric current produced always flows in one and the same direction and has a constant strength, it is known as continuous current or direct current (D.C.) and the machine that produces it is known as direct current dynamo or D.C. Dynamo or Generator.

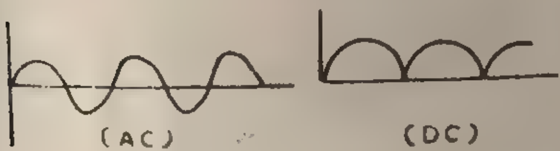


Fig. 6.20. (a) and (b).

6.13. Electric Circuit :

Electricity travels along a path. If the path is broken off, then electricity cannot travel. The whole path along which electricity travels is known as a circuit. Let us see how electricity travels.

Activity 6.7.

You will need the materials shown in Fig. 6.21. Connect your materials as shown in Fig. 6.22 to light the bulb. Use adhesive tape to stick the ends of the wire to the dry cell.

What happens when you have finished your connections ? Does the bulb light up ?

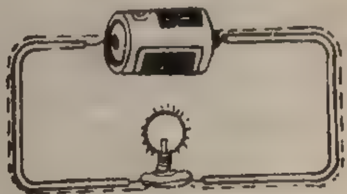
With your finger trace the path of the electricity from one end of the battery to the other. Where does the path end ? Is the path broken ?

An unbroken path travelled by electricity is known as a closed circuit.

Disconnect one of the wires. Again trace the path of the electricity. Is the path of the electricity broken ? Does the bulb light up ?

Fig. 6.21. (a)

Fig. 6.21. (b)



A CLOSED CIRCUIT

Fig. 6.22.

A broken path is known as an open circuit. Electricity will not flow in an open circuit. (Fig. 6.23).

Fig. 6.23.

6.14. Effects of electric current

We generally observe the following effects of electric current in our daily life :

(*a*) It produces heat as in the case of electric irons, electric kettles, electric ovens, etc.

(*b*) It produces light as in the case of electric lamps and torchlights etc.

(*c*) It produces sound as in the case of radio and telephone.

(*d*) It produces motion as in the case of electric motors and electric fans.

(*e*) It produces magnetism as in the case of electromagnets which are widely used in industry.

We can continue our list endlessly, but we will notice that many of the items are either a repetition or a by-product of another one. For instance, (*b*) and (*c*) above arise from (*a*) because light is not produced unless the wire is hot and sound is not produced in radios unless the tubes are heated to give out electrons ; (*d*) and (*e*) are also the same. It is therefore, possible to group all the effects you can think of under three main headings :

1. Magnetic effect.
2. Heating effect.
3. Chemical effect.

Let us examine them experimentally.

Magnetic effect

Activity 6.8.

Take an iron nail. Use a piece of insulated wire and wind it round the iron nail (40 windings at least) leaving the two ends of the wire free. Connect the two bare ends to a battery Fig. 6.24. Now switch on the circuit. Put the iron nail near pins or clips. What happens ? The pins or the paper clips are attracted to the iron nail. The nail is behaving like a magnet.

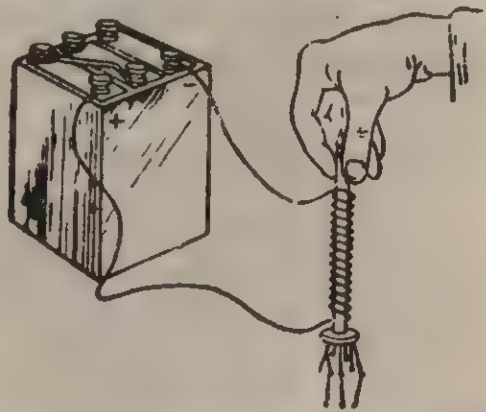


Fig. 6.24.

Switch off the circuit. Do the pins or clips drop off ? They do. This means that there is no magnetism in the iron nail any more.

When electricity is passed through the wire wound round the nail, magnetism is produced. We do not get the magnetic effect if no electricity passes through the wires. Thus we can say that electricity can produce magnetism.

Heating effect

Put your hand near a lighted electric bulb for a while. Can you feel the heat coming from the bulb ?

Connect an electric stove to an electric current. Switch it on. After a few minutes place your hand near the stove. What do you feel ?

Can you name a few more electrical appliances where electricity is used to produce heat ?

Activity 6.9.

Take short lengths of copper wire and nichrome wire of standard gauge (SWG 30) and place them in the circuit as shown in Fig 6.25. A dry

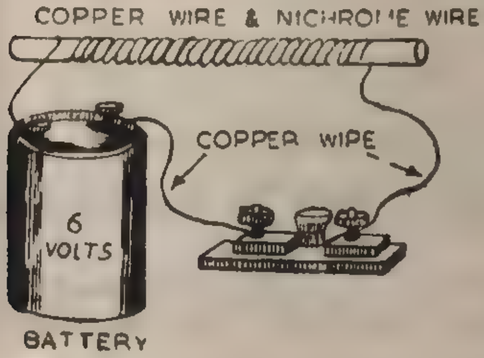


Fig. 6.25.

cell and a switch are connected to the two free ends of the copper wire and the nichrome wire as shown. When the switch is on and the current is allowed to flow for some time, place your hand near the wires. What do you feel ?

You will notice that the nichrome wire becomes red hot and the copper wire will become warm.

Thus it is clear that when an electric current flows through conductors, heat is produced and the heat produced depends upon the metal used.

Chemical Effect

You must have used silver-plated spoons and tin-plated cans and you have seen chromium-plated bumpers and door handles in cars. They are the results of the chemical effect of electricity.

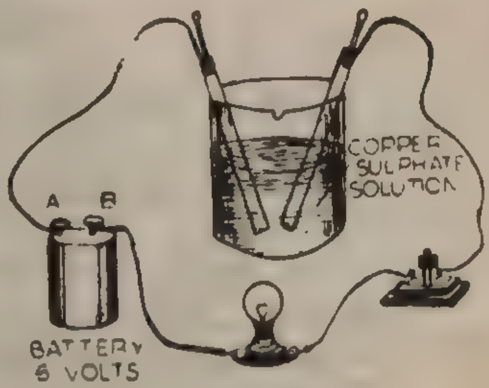


Fig. 6.26.

You know that solutions of mineral salts, acids and alkalies (electrolytes) will allow electricity to pass through them, while other liquids, such as distilled water, oils and solutions of organic substances like sugar and alcohol (non-electrolytes) do not conduct electricity. We shall now examine more closely what happens

when an electric current is passed through an electrolyte.

Activity 6.10.

Take a dry cell, a small torch bulb, switch and two copper plates. Connect the circuit as shown in Fig. 6.26. The switch should be on. Touch the copper plates. Does the bulb glow ? Does it imply that by touching the plates you can close the circuit ?

You will observe that *some chemical* change takes place in the copper sulphate solution when an electric current flows through it. The metallic film of copper on the plate comes from the copper sulphate solution and the passage of electricity through copper sulphate solution has produced a chemical effect by separating the metal from its salt.

The process of producing a chemical action in liquid by the passage of electricity through it is known as *electrolysis.* Electrolysis finds many applications in industry *e.g.*, electroplating, production of copper, aluminium and a number of other metals etc. The storage battery also works on the principle of chemical effect of electric current. The rusting of iron is prevented by electroplating it with nickel or chromium.

The unit of charge

The unit of charge is **coulomb.**

SUMMARY

1. All bodies when rubbed together are said to be *charged* or *electrified.*

2. There are two, and only two different kinds of charge—positive and negative.

3. Like charges repel and unlike charges attract.

4. A body need not necessarily be rubbed with another body to be charged. It is quite sufficient to touch it with some other charged body.

5. Electroscope is a device by means of which we are able to detect and identify charges.

6. The materials that allow electricity to flow through them easily are called *conductors* and those through which it is difficult for electric charge to flow are called *insulators.*

7. The electric condition of a conductor which determines the flow of electric charge from it to another conductor placed in contact is known as its electric potential.

8. Flow of electric charge is called an electric current and an electric current flows only when there is an electric potential difference.

9. The whole path along which electricity travels is known as a *circuit.*

10. The various effects of electric current are : Magnetic effect ; (*ii*) Heating effect ; (*iii*) Chemical effect.

11. The unit of charge is **coulomb.**

QUESTIONS

1. Three rods—copper rod, plastic rod and glass rod—have been rubbed with a silk cloth. Which rod or rods will be left with an electric charge and why ?

2. Which way would you expect the suspended rod to move ? (Fig. 6.27).

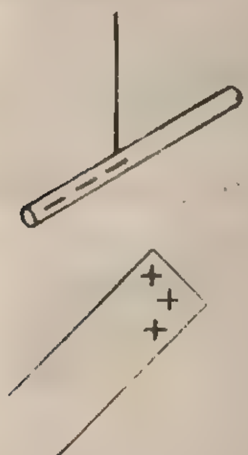


Fig. 6.27.

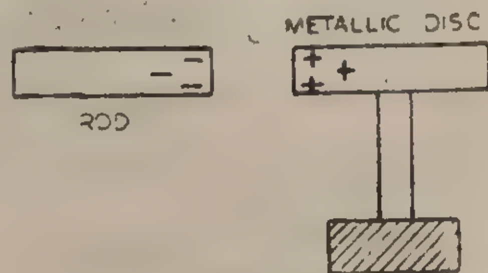


Fig. 6.28.

3. The negatively charged rod, when brought up to the metallic disc induces a positive charge on part of the disc near to it (Fig. 6.28). How could you arrange for the disc to remain positively charged when the rod is removed ? Why does this happen ?

4. Why can an ebonite rod be charged by rubbing while holding it in the hand but a metal rod cannot ?

5. It is found that an object A repels object B, A attracts C and E repels D. If you know that D is positively charged, what kind of charge does B have ?

6. What will happen if you touch together the knobs of two identically and equally charged electroscopes :

(*a*) If both are positively charged ?

(*b*) If both are negatively charged ?

(*c*) If one is negative and the other is positive ?

7. Must all the negative charges be removed in order that a rod becomes positively charged ? Explain.

8. Arrange the following materials in order starting with the best conductor and ending with the best insulator :

Copper ; silver ; salt water ; oil ; aluminium ; tungsten ; glass.

9. A gold leaf electroscope is used for detecting electric charge. Why do the leaves fly apart when a charged body is placed on the disc ?

10. How could you demonstrate that there are two distinct kinds of electric charges ?

11. Distinguish between conductors and insulators giving *three* examples of each.

12. What is a lightning conductor ? Explain its action.

13. (*a*) What are the various sources of electrical energy ?

(*b*) What is the main advantage of using a dry cell as a main source of electric current ?

(*c*) What is the advantage of connecting the dry cells in Series ?

14. Classify the following effects of electricity under the headings : magnetic, chemical and heating :

(*a*) The telephone is worked by electricity.
(*b*) Electricity can work an electric bell.
(*c*) Electricity produces light.
(*d*) Electricity is used in the electric iron.
(*e*) Electricity can work a refrigerator.
(*f*) Electricity can work an electric fan.
(*g*) Electricity can work a radio.
(*h*) A car can be started by electricity.

15. Show by a simple experiment that when current flows inside a wire, magnetic effect is noticed near it.

16. How can you show by a simple experiment that electricity produces heat ?

List a dozen ways in which the heating effect of electricity has been used.

17. How can you show by a simple experiment that electricity produces chemical effect ?

18. Classify the following under :

(*a*) electrolytes

(*b*) non-electrolytes.

Distilled water, common salt solution, sulphuric acid ; copper sulphate solution ; orange juice.

Is mercury an electrolyte ?

19. Fill in the blanks :

(*i*) Most of the electric wires we come across are covered with ....or..................

(*ii*) Some of the electric bells work with the electric current from the..................and others on electric current from.................. or..................

(*iii*) The telephone is worked by..................

(*iv*) An electric bulb has..................points for contact with the bulb holder and the bulb is connected to the..................again with ....wires.

(*v*) Electric current produces..................effects.

(*vi*) ....is a device by means of which we are able to detect and identify charges.

(*vii*) A body need not necessarily be..................with another body to be charged. It is quite sufficient, for instance, to..................it with some other..................body.

(*viii*) The divergence of the leaves of an electroscope indicates the ....of an..................

(*ix*) Telegraph and telephone wires are made of copper as they are good..................

20. Write 'T' against the sentences which are True and 'F' against the sentences which are false in the following statements :

(*a*) All bodies when rubbed together are said to be charged or electrified. ....

(*b*) The materials that allow electricity to flow through them easily are called insulators. ....

(*c*) Electricity can not work an electric bell. ....

(*d*) There are two different kinds of charge. ....

(*e*) Franklin showed that clouds and the earth store electricity. ....

(*f*) Temperature may be defined as the degree of electrification of a charged body. ....

(*g*) Earth is a good conductor of electricity but has no capacity for electric charge.

7

MAGNETISM

7.1. Introduction to Magnets :

Long ago, the story goes, a shephered boy was keeping his sheep on a hillside near a Greek city called Magnesia. A great storm arose. The boy ran for shelter to a cave. He held his crook (a stick with an iron handle) in his hand. When he got into the cave his crook was snatched from his hand. The boy did not see anyone. He was very frightened. He saw his crook hanging from the roof. He got it back after some struggle. He thought that the roof of the cave had some strange power. Whenever he held his crook up towards the roof, it jumped out of his hand and hung there. But when the turned it up-side down and held the wooden end up towards the roof, nothing happened. Again, when he held the iron head of his crook towards the roof, it jumped out of his hand. Only the iron end held there.

This strange thing puzzled the boy. When the storm was over, he tried to find the answer but he did not succeed. At last a wise old man explained it to him. The roof of the cave was made of a black rock with iron in it. The iron had special powers. It could attract other pieces of iron, which had not got this power, to itself.

Years later, this iron rock came to be called Magnetite, a dark coloured ore, composed of iron and oxygen (Fe_3O_4). Look at the first six letters of the word magnetite. What do they spell ?

This is where the story of magnets begins. Magnetite was known from ancient times to possess the following *two characteristic properties* :

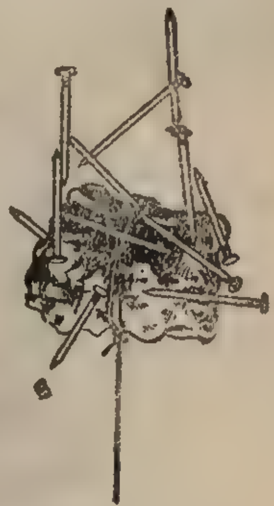


Fig. 7.1. Lodestone.

(*i*) **Attractive Property.** When a lump of magnetite is brought in contact with small pieces of iron, it picks them up.

(*ii*) **Directive property.** When a bar of magnetite is suspended freely at the end of a fine thread, it oscillates to and fro and finally comes to stay with its two ends always directed along the north and the south of the earth approximately.

This directive property was used by the ancient sailors to guide the course of ships on the sea. Hence, they called magnetite a Lodestone, which means a leading stone.

Any substance which, like the lodestone, has the above mentioned two characteristic properties *i.e.*, attractive and directive, is called a magnet.

Since magnetite can be mined from the earth it is called a natural magnet and is found in many places *e.g.*, Canada, Finland, Norway, etc.

Natural magnets like the lodestone are irregular in shape and have weak attractive and directive properties.

Magnets can also be made by artificial means and such magnets are called artificial magnets. Magnets are made of different materials. Many magnets are made of iron and steel. Some magnets are made of mixtures of aluminium, nickel, cobalt and iron and have trade names such as Alnico. Such magnets are very strong. Ferrite magnets are made from a powder of iron oxide and either barium oxide or strontium oxide. These magnets are brittle and have the properties of ceramics. Magnets are of many shapes. Some are cylindrical rods and some are rectangular bars. They are called 'bar magnets'. Some are U-shaped. Some are called 'horse-shoe magnets' be

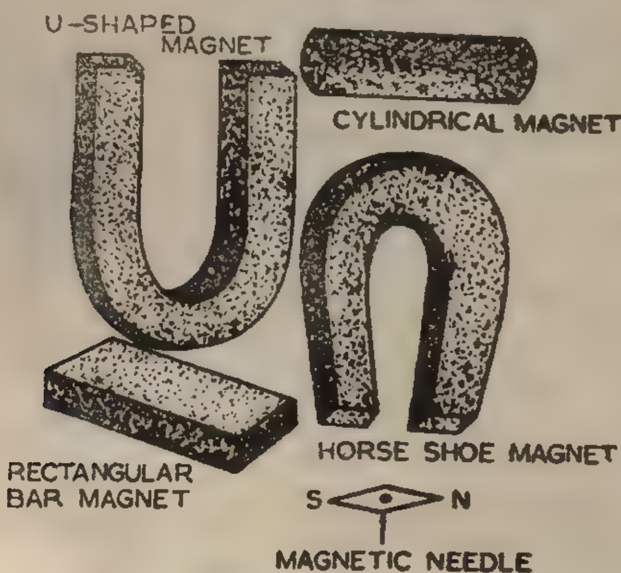


Fig. 7.2. Magnets of different shapes

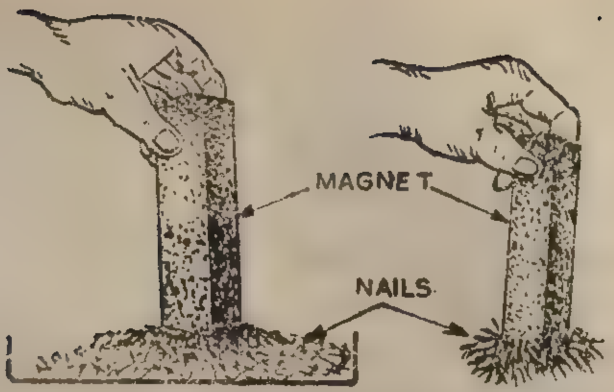


Fig. 7.3 Magnets attract magnetic substances

cause they look like horse-shoes. One is a thin piece of magnetised steel with two tapering ends kept balanced on a vertical pivot called the *magnetic needle*.

7.2. Magnetic and non-magnetic materials :

A substance which is attracted by a magnet is called a magnetic substance. A substance which is not attracted by a magnet is called a non-magnetic substance. A magnetic substance can be made into a magnet whereas a non-magnetic substance cannot be made into a magnet.

Activity 7.1 :

Use a magnet to find out whether the following substances are magnetic or non-magnetic :

1. Ruler	2. Pencil
3. Comb	4. Tin
5. Glass	6. Nail
7. Screw-Driver	8. Coin
9. Scissors	10. Matchbox
11. Chalk	12. Cork
13. Thumb tack	14. Eraser
15. Clothes peg	16. Rubber band
17. Copper wire	18. Plastic tooth-brush.

7.3. Magnetic Poles—The strongest parts of a magnet :

A magnet has an attractive force on magnetic materials. Is the attractive force the same all over a magnet ?

Activity 7.2 :

Place a bar magnet in a container having steel clips in it. Pick up the magnet.

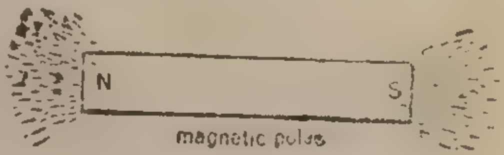


Fig. 7.4. Poles of a bar magnet

Do any clips cling to the magnet ? Where do most of the clips cling ? By raising the magnet you will see that the clips cling to it in an irregular fashion. Most of them cling to the ends of the magnet. This experiment shows that the ends of the bar magnet

have greater magnetic force than the middle portion of the magnet. Repeat the experiment with U-shaped, horse-shoe and cylindrical magnets. Do the ends of the magnets have greater magnetic force than the other parts ?

The two regions on a magnet which attract more clips are called *Poles* of a magnet.

There is a magnetic pole at each end of a magnet. Always there are two magnetic poles on a magnet, no matter what its shape may be.

Suppose, now a bar magnet is suspended by a thread of unspun silk or supported on a large cork floating in a dish containing water. The magnet will be seen to turn and eventually

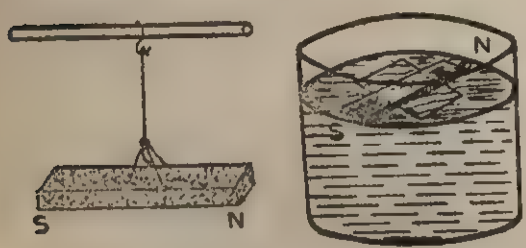


Fig. 7.5.

come to rest pointing north and south of the earth. If the end of the magnet pointing north is marked in some way, it will be found that the same end always points northwards. The pole at this end is called the *north-seeking pole* or more often simply the *North-pole* (*N-pole*). The other pole of the magnet is then called the *south-seeking* or *South pole* (*S-pole*).

7.4. Interaction of Magnets—Attraction and Repulsion :

Activity 7.3. :

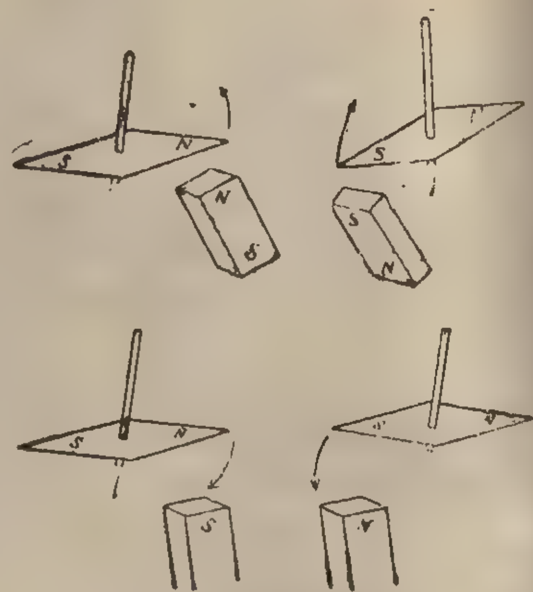


Fig. 7.6.

Take a piece of unspun thread and two bar magnets. Hang one magnet as shown in Fig. 7.6 so that it can rotate freely. The magnet will be seen to turn and eventually come to rest pointing north and south.

Now :

(*i*) Bring the north pole of a second magnet near the North pole of the hanging magnet. What happens ?

(*ii*) Bring the north pole of the second magnet near the south pole of the hanging magnet. What happens ?

(*iii*) Bring the south pole of the second magnet near the north pole of the hanging magnet. What happens ?

(*iv*) Bring the south pole of the second magnet near the south pole of the hanging magnet. What happens ?

You will observe that the north pole of a magnet will attract or pull the south pole of another magnet towards it. The south pole of a magnet will attract the north pole of another magnet. Therefore, unlike or different poles attract. The north pole of a magnet will repel or push the north pole of another magnet. The south pole of a magnet will also repel the south pole of another magnet. Therefore like poles repel. This is a basic property of magnetism which may be stated as follows :

'Like poles repel, unlike poles attract'.

The action of a magnet upon another magnet is known as *magnetic interaction*. The magnetic interaction can be used to determine the poles of a magnet. Bring the end of a magnet to the north pole of a hanging magnet. If the north pole of the hanging magnet is attracted towards the end of the magnet, the end of the magnet is the south-pole and the other end is the north-pole.

7.5. Magnetic Field

A magnet exerts a force on magnetic substances placed near it. The force is greatest at the poles of the magnet itself. The force is also felt outside the magnet. The region round the magnet in which the magnetic force can be felt by a magnetic substance is called the *magnetic field* of the magnet. You cannot see a magnetic field but you can see what the force in a magnetic field can do.

Activity 7.4 :

(*i*) Sprinkle some iron filings on a white cardboard. Move a bar

Fig. 7.7.

magnet just below the board (Fig. 7.7). Do the iron filings move with the magnet ? If they do, the iron filings are in the field of the bar magnet.

(*ii*) Move the magnet further away from the board. Do the iron filings move as the magnet is moved about ? If they do not, the iron filings are not in the field of the bar magnet.

7.6. Simple Methods of Producing Magnets

We can make our own magnets. Let us find out how we can do this.

Activity 7.5.

(*i*) *Making a magnet by induction.*

Take a magnet, a large nail and some paper pins. Touch the pins

with the iron nail. Does the iron nail attract the pins ?

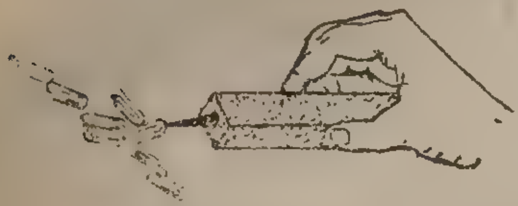


Fig. 7.8.

. Now place the magnet, the nail and the pins in a line. Move the pins closer to the nail. What happens to the pins ? Take the magnet away. Does the nail still attract the pins ? Does the nail still attract the pins a little while later ?

The nail becomes a magnet by induction.

(*ii*) *Making a magnet by stroking.*

Fig. 7.9. Direction of movement

Take a magnet, a steel knitting needle and some pins. Put the knitting needle on a table and then stroke it with a magnet. Stroke the knitting neddle in one direction, from one end of the needle to the other, using the same pole of the magnet all the time (Fig. 7.9). Do this about 30 times. Pick up some pins with it. Your knitting needle has now become a magnet.

Does the knitting needle still attract the pins a little while later ?

7.7. Types of Magnets

There are two kinds of magnets :

(*i*) Temporary magnets

(*ii*) Permanent magnets.

Temporary magnets are usually made of iron and are able to keep their magnetism for a short time only. Permanent magnets are usually made of steel and are able to keep their magnetism for a long time.

Fig. 7.10. Temporary and Permanent magnets

7.8. Magnetic Compasses

Finding your way in a big city is easy because streets, buildings and roads differ so much that it is easy to give or follow directions. But it would be difficult to find your way through a thick forest. You would have still more difficulty on the ocean because there is almost nothing to guide you. Yet, you know that explorers can find directions in dense

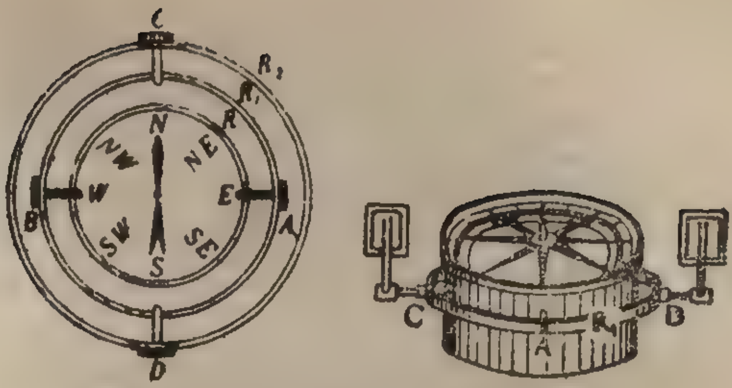


Fig 7.11. Mariner's Compass

jungles, sailors and pilots cross the trackless oceans without difficulty. Do you know how they are guided in their directions. Sailors have used compasses for centuries to help them steer their ships in the right direction. Air-planes have compasses too. Mountaineers, hunters and scouts carry compasses and know how to use them.

In a magnetic compass, the magnetic needle is supported in such a way that it can rotate freely. When the compass is placed at rest, the needle will come to rest in the north and south direction. The two ends of the needle are marked differently so that we can know which is the N-pole of the needle, and which is the S-pole. The compass is provided with a circular scale below the neddle. The axis of the needle passes through the centre of this circular scale. The scale has all the cardinal points marked on it. All these components are enclosed in a case having a glass cover.

While adjusting the compass for correct setting, one should be careful to remove all iron and steel objects near the compass as their presence will affect the reading. Two compasses which are commonly used are the Pocket Compass and the Ship's Compass (Mariner's Compass) Fig. 7.11.

7.9. Earth's Magnetism

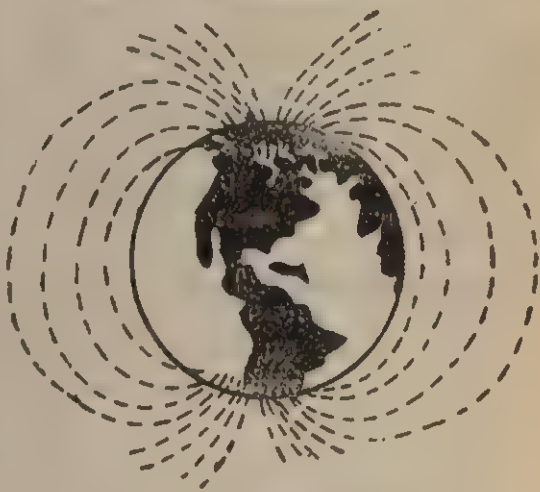


Fig. 7.12. Magnetic field of the Earth

When a bar magnet is hung freely, it comes to rest in a north-south

direction. Another bar magnet hung in the same way, some distance away, will also come to rest in the same direction as the first magnet. The reason the bar magnets come to rest, in a north-south direction is because of the Earth's magnetism. There is a very large magnetic field all round the Earth. This magnetic field acts upon the magnet and brings it along the north-south direction. Fig. 7.12 gives schematic diagram of the magnetic field round the earth. The magnetic lines of force indicate that the magnetic fields seems to be produced by a huge magnet in the Earth, with its south pole pointing towards the geographical north and its north pole pointing towards the geographical south. Scientists are still not certain how the Earth got its magnetism. Some say it might be due to deposits of magnetic materials.

The magnetic poles of the Earth are not at the same positions as the geographic north and south poles. They are a short distance away from each other. Any place on Earth would have a geographic meridian and magnetic meridian.

7.10. The Care of Magnets

Magnets can lose their magnetism if you do not take proper care of them.

(*i*) You should not heat a magnet or place it near a fire.

(*ii*) You should not drop a magnet or knock it.

(*iii*) When you are not using magnets, you should protect them with magnetic keepers.

Fig. 7.13.

A magnetic keeper is a piece of soft iron which is usually placed across the poles of a horse-shoe magnet. Bar magnets are kept in pairs with opposite poles side by side having a soft iron piece placed across the poles at each end when the magnets are not in use (Fig. 7.13). How will magnetic keepers keep the, magnetism intact ?

7.11. Some Uses of a Magnet

(*i*) Boy scouts use a small compass during the field trips. It helps them to find the direction.

(*ii*) Some of the shopkeepers use a magnet to detect a base coin.

(*iii*) Magnets can be used in the construction of certain toys to give magic like effect.

(*iv*) A chart can be fixed to an iron sheet with the help of small magnets at the four corners.

SUMMARY

1. Any substance which like the load-stone has two characteristic properties, *i.e.*, *attractive* and *directive* is called a *magnet.*

2. Natural magnets like the loadstone are irregular in shape and have weak attractive and directive properties.

3. Artificial magnets are those magnets which can be made by *artificial means.*

4. A substance which is attracted by a magnet is called a *magnetic substance.* A substance which is not attracted by a magnet is called a *non-magnetic* substance.

5. A magnetic substance can be made into a magnet whereas a non-magnetic substance cannot be made into a magnet.

6. The two regions on a magnet which possess the maximum attractive power are called the *poles* of a magnet.

7. There is a magnetic pole at each end of a magnet. There are always two magnetic poles on a magnet, no matter what its shape may be.

8. Like poles repel, unlike poles attract.

9. The action of a magnet upon another magnet is known as *magnetic interaction.*

10. The region round a magnet within which its influence can be felt by a magnetic substance is called the *magnetic field* of the magnet. You cannot see a magnetic field but you can see what the force in a magnetic field can do.

11. A magnet has an attractive force, this magnet force is able to pass through certain substances.

12. We can make our own magnets by *induction* and by *stroking.*

13. There are two kinds of magnets : Temporary magnets and Permanent magnets.

14. Magnets can lose their magnetism if you do not take proper care of them.

15. Sailors, pilots, explorers, hunters, scouts use compasses to find directions.

16. Earth behaves like a huge magnet. The cause of Earth's magnetism is still not known to the Scientists.

QUESTIONS

1. A compass, whose needle will normally point to the magnetic north, is placed next to a magnet as shown in Fig. 7.14. Copy the diagram, showing the compass needle and the direction in which it will point.

Fig. 7.14.

2. Fig. 7.15 is a diagram of the magnetic field of a horse-shoe magnet. Mark its poles.

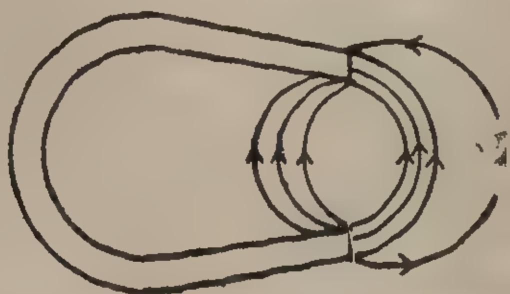


Fig. 7.15

3. Is the field shown in Fig. 7.16 stronger at A or at B. What do the lines and arrows show ?

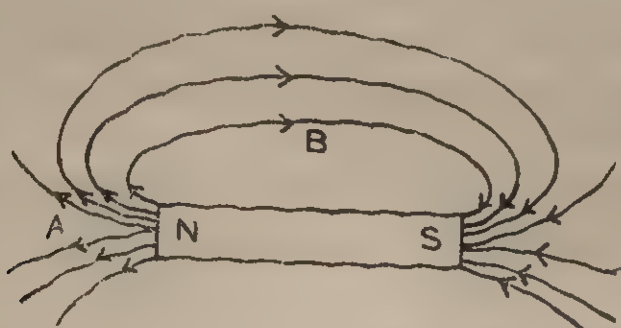


Fig. 7.16.

4. What is the difference between a natural magnet and an artificial magnet ? Mention examples of each.

5. What is the difference between a magnet, a magnetic substance and a non-magnetic substance ?

Classify the following under (*a*) Magnetic and (*b*) Non-Magnetic :

Lead, aluminium, nickel, brass, copper, cobalt, silver, iron, zinc, steel, sulphur and carbon.

6. How can you show that a magnet will act through non-magnetic substances provided they are not too thick but not through magnetic substances ?

7. Describe two ways of magnetising an iron knitting needle and three ways of demagnetising it.

8. State the law of magnetic attraction and repulsion.

Given a compass needle show how you can use this law to differentiate between three identical iron rods, one of which is a magnet, the second a non-magnet but made of a magnetic substance and the third a non-magnetic substance.

In what other way can you differentiate between the three identical rods ?

9. What is a magnetic field ? Can it be seen ? Can it be detected ? Can a magnetic field be mapped out ?

10. What are magnetic poles ? Is a magnetic pole a point ? Can a magnet have one pole only ?

11. Discuss the following statement :

'The N-pole of a magnet is attracted by the N-pole of the Earth, from which we conclude that like poles attract.'

12. Why is a horse-shoe magnet often supplied with a 'keeper' ?

13. A magnetised needle is floated on a dish filled with water. Will it drift northward ? Explain.

14. What is a loadstone ? How does the behaviour of a loadstone differ from that of an ordinary rock ?

15. What are the common uses of magnets ?

16. What is a compass needle ? Why does it point in the north-south direction ?

17. Complete the following sentences :

(*i*) A bar magnet has a.... ....at each of its ends.

(*ii*) Magnets are of different................and.................

(*iii*) A piece of...............can be easily................by using a.................

(*iv*) ....during the day and...............at night help us to get an idea of the directions.

(*v*) Our earth has some deposits of................materials due to which it behaves like a................

(*vi*) ....magnets are made of some powdered materials pressed together and brittle. These magnets are very................and are of different................

(*vii*) Boy scouts use a small................during their field trips. It helps them to find the................

(*viii*) If both the ends of a permanent magnet attract an unknown piece of steel, it is................

(*ix*) Any object which has power of attracting iron is called a ....

NATURE AND COMPOSITION OF SUBSTANCES—I

8.1. Molecules

Solids, liquids and gases are all made up of particles (tiny bits of matter) called atoms. Atoms are so small that no body can see them, even with the most powerful microscope. They themselves are made of even smaller particles called neutrons, protons and electron. Neutrons and protons are packed together in the nucleus, or core, of the atom. Electron travel around the nucleus, rather like planets going round the sun.

In most substances, atoms are joined together forming groups called *molecules*.

If you light an agarbatti in a corner of a room, you can soon smell it all over the room. The smoke from the agarbatti spreads all round the room. This indicates that the gas molecules must have travelled from the agarbatti to the nose. Similarly, the movement of molecules of ink tablet can be seen by dropping them in a glass of water.

8.2. Forces between molecules—Change of state

There are three states of water (*i*) solid, (*ii*) liquid and (*iii*) gas. How can these three states of water be distinguished from each other ?

A solid is a form of water with a definite shape and a definite volume. A liquid has a definite volume but does not have a definite form or shape. A liquid takes the shape of its container. Water, gasoline, and alcohol are liquids at room temperature. A gas does not have a definite shape or volume. It takes the shape and volume of its container.

A substance may exist as either a solid, liquid or gas. The form of a substance depends upon the temperature and pressure. Change in temperatures can cause changes in the properties of substances.

8.3. Physical Changes

Matter sometimes changes without any re-arrangement of the atoms. Such changes are called Physical changes. When ice melts, it goes through a physical change. It turns into water. But this water is made up of the same molecules as those found in ice. In both cases, each

molecule has the hydrogen atoms and one oxygen atom.

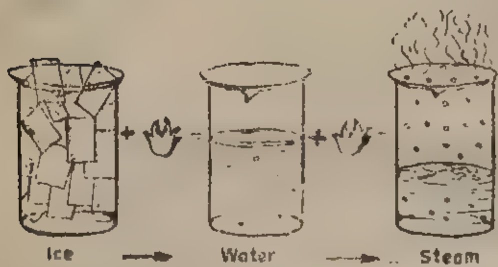


Fig. 8.1. Change of state on heating

When water boils, another physical change takes place, the water turns into steam. The steam molecules, are still the same as the molecules of water and ice. But the molcules behave differently in each case.

In ice, molecules are tightly bound together by electric forces. Although the molecules make tiny quivering movements all the time, they cannot move around in the solid ice. But when ice is heated, the molecules quiver faster and faster. Eventually, they break away from their fixed positions and move about. This is the point at which ice melts and becomes water. When the water is heated, the molecules move even faster. In the end, they break away from the other molecules, and move about freely. This happens when water boils.

In solids, atoms or molecules are tightly bound together by forces of attraction.

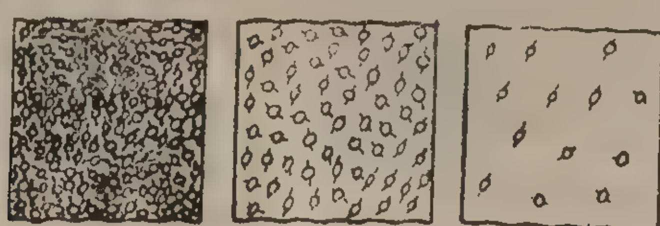
In liquids, the forces of attraction are less and atoms or molecules are able to slide around.

In gases, attraction is so slight that atoms or molecules move about freely and quickly.

8.4. Movement of Molecules :

Put one or two drops of scent on your handkerchief and wave it. Your friend can easily smell the scent at a distance. Why ? This is because the molecules of scent are moving in all directions.

We see dust particles, moving in the beams of sunlight entering a dark room. We find that the movement is constant and haphazard. The visible movement of the particles in due to the fact that the molecules present in air are in a constant state of motion and hence go on hitting the dust particles at random with great speeds.



(a) (b) (c)

Fig. 8.2. Intermolecular spaces in the three states of matter : (a) solid state, (b) liquid state and (c) gaseous state.

Fig. 8.3 Beam of sunlight entering a dark room

Since numerous molecules are constantly bombarding the dust particles from all possible directions, this results in a continuous and irregular motion of the particles. This movement of particles is called *Brownian movement* after the name of the scientist, Robert Brown.

The movement of molecules in a liquid can be seen by dropping crystals of Potassium Permanganate in a beaker of water. After sometimes, the colour spreads throughout the water in the glass. The movement of molecules is known as diffusion.

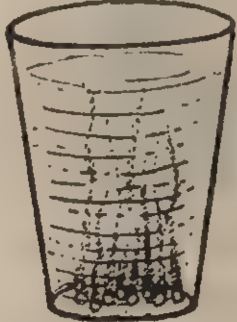


Fig. 8.4. Diffusion of solid in water

8.5. Elasticity and Plasticity

Apply force on rubber band, aluminium strip, common salt crystal, atom crystal etc. See what happens ?

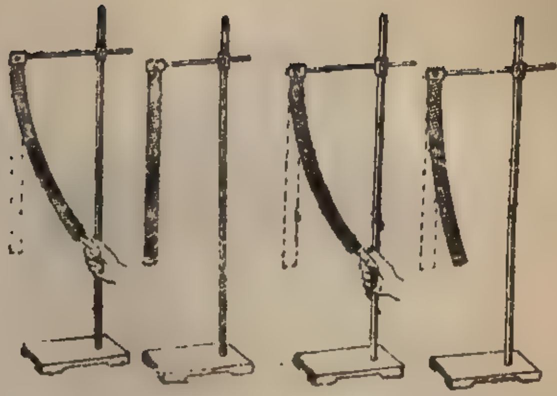


Fig. 8.5. A deformed steel strip when the force is released, it regains its original shape.

You will see that rubber band can be stretched and steel strip can be bent. But when force is released they regain their original shape.

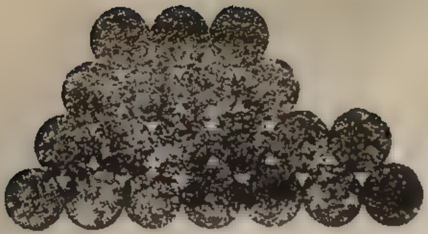
The property of a substance to regain its original shape, after the force ceases to act on it, is called *Elasticity*.

An aluminium strip also bends like a steel strip but it does not regain its original shape after the force ceases to act on it.

The property of a substance to remain in a new shape after the force ceases to act on it is called *Plasticity*.

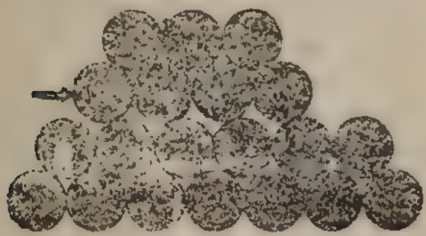
Molecules of solids are tightly packed and are arranged in a particular order. The deformation of bodies is connected with the changes in the arrangement of molecules.

Let us consider the model of a solid body with glass beads as its 'molecules'. If we apply some force



Four rows of glass beads arranged to form a word of a solid body.

The force applied on the row in a deformation of the body.



The small deformation disappears when the force ceases to act.

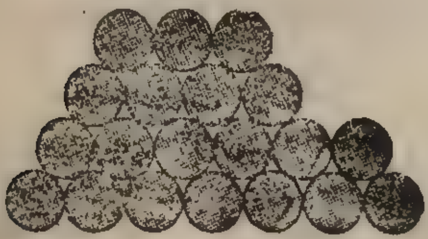


Fig. 8.6.

on its upper part, we shall notice that gaps between some of the 'molecules' and their neighbouring 'molecules' increase and the body is deformed. But after the force ceases to act, these 'molecules' return to their original position due to the force of molecular attraction and the body regains its original shape.

8.6. Chemical Reaction

The change that Priestley and Lavoisier observed when they heated mercury was a chemical change. The mercury combined with oxygen from the air to form a new substance called Mercuric Oxide. In a chemical change, the chemical properties of a substance are changed and new and different substances are formed. The substance or substances formed have properties different from the properties of the materials that combined during the change.

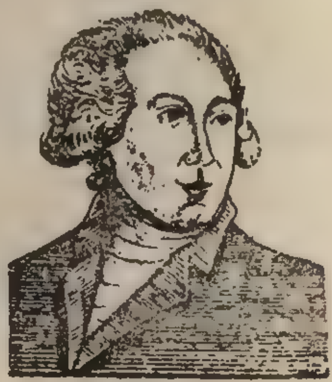


Fig. 8.7. Antoine Lavoisier (1743—94)

Mercury is a silvery liquid and oxygen is a colourless gas. When combined in a chemical change, they produce a red solid, mercuric oxide.

Mercury + Oxygen→Mecuric Oxide

The process in which a substance undergoes a change under certain conditions in which new substances are formed is called *Chemical Reaction.* These changes depend upon the nature of the substance, that is the molecules of which it is made of.

8.7. Conditions needed for a chemical reaction

Quick lime reacts with water only when the two substances are brought in contact with each other. One of the conditions for a chemical reaction to start is *direct contact* of the substances. Many reactions would start only when heat is given, *e.g.*, burning of Magnesium. Some would take place only in presence of light *e.g.*, Photosynthesis. Rocks are changed by the action of water and air.

Conditions under which chemical reactions take place are quite varied.

These are :

(*a*) *Contact.* When sodium comes in contact with water.

(*b*) *Heat.* Melcuric oxide does not decompose to give oxygen unless it is heated.

(*c*) *Light.* Photosynthesis in green leaves takes place only in light.

(*d*) *Electricity.* When electric curent is passed through water it decomposes into hydrogen and oxygen.

(*e*) *Pressure.* When two stones strike with each other it produces spark.

(*f*) *Catalyst.* Certain reactions can be brought about much faster by using a substance known as catalyst *e.g.*, oxygen is given off very quickly and without strong heating when you mix some manganese dioxide with potassium chlorate.

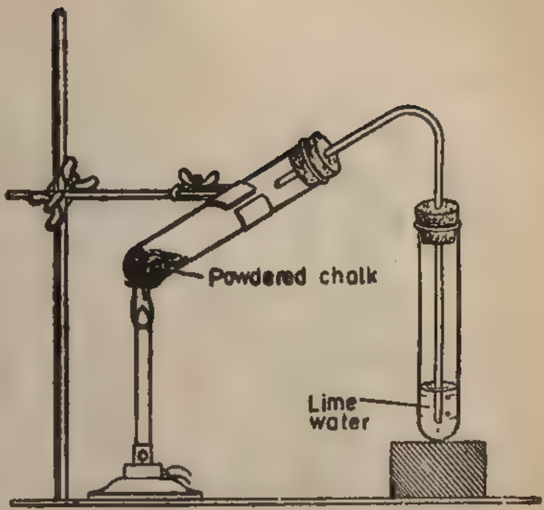


Fig. 8.8. Heating copper carbonate in a test tube and passing the gas evolved through lime water.

8.8. Decomposition Reaction

Heat copper carbonate in a boiling tube for a few minutes and observe the change that occurs. Pass the gas through lime water.

We see that when basic copper carbonate is heated, three new substances are formed—a black solid (copper oxide), a liquid (water) and a gas (carbon dioxide).

$$\text{Copper carbonate} \xrightarrow{\text{heat}} \text{copper oxide} + \text{carbon dioxide} + \text{Water}$$

Here in this case molecules of copper carbonate are decomposed to form molecules of copper oxide, water and carbon dioxide.

8.9. Electrolysis

Pass an electric current in water

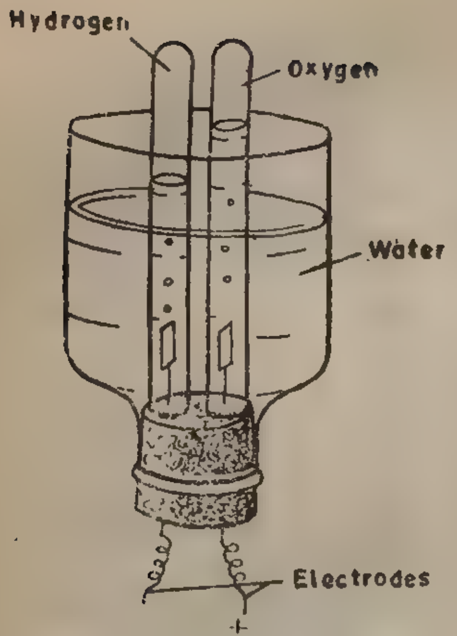


Fig. 8.9. Decomposition of water by the electric current.

containing a little acid or common salt. Pour the water containing some acid into the cup of the apparatus. Fill two test tube with water and invert them over the two electrodes made of steel or carbon. Connect the two terminals to a 6 volts battery.

Now introduce a glowing splinter into the test tube having the smaller volume of gas. The splinter bursts with a flame, showing that the gas is oxygen. Bring burning splinter to the mouth of the other test tube and see that it burns with a 'Pop' sound. This gas is hydrogen. The volume of hydrogen is twice that of oxygen.

$$\underset{\text{(liquid)}}{\text{Water}} \xrightarrow{\text{electric current}} \underset{\text{(gas)}}{\text{Oxygen}} + \underset{\text{(gas)}}{\text{Hydrogen}}$$

Such a decomposition reaction which takes place by the passage of electric current is called electrolysis.

8.10. Combination Reaction

When two or more substances combine together to form new substances, it is called *Combination Reaction.*

$$\underset{\text{(dark grey)}}{\text{Iron}} + \underset{\text{(yellow)}}{\text{Sulphur}} \xrightarrow{\text{Heat}} \underset{\text{(black)}}{\text{Iron Sulphide}}$$

Mix iron and sulphur powder. You will see that there is no change. Now heat the mixture and observe the change. You will notice that the product of the chemical reaction differs from the initial substances (reactants). It has a different colour and it sinks in water without getting separated with sulphur and iron. Even iron will not be attracted by a magnet (See Fig. 8.10).

The substances sulphur and iron

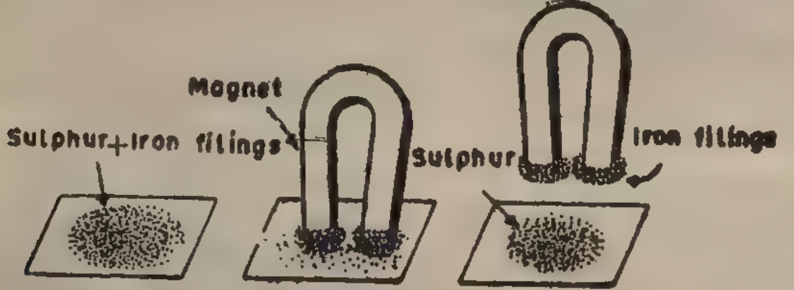


Fig. 8.10. Iron present in a mixture of iron and sulphur is attracted by a magnet.

have lost their original properties. A new substance, iron sulphide, having its own characteristic properties, is formed.

8.11. Chemical elements and symbols

Scientists have discovered that substances of the world are composed of at least 103 elements. These 103 known elements are the building blocks of matter. An element is any substance which in its pure form can not be separated into simple substances. Mercury and Oxygen are both examples of elements as are Gold, Iron, Copper etc.

Most of the elements known today have been discovered in nature. The remainder have been made by scientists in laboratories. It is quite probable that man will continue to produce new elements. This is an example of the progress of science.

In chemistry, a letter or group of letters used to represent an element is called a symbol. A symbol for an element is either one capital letter or two letters, the first of which is capitalized. For example O is the symbol for Oxygen, Hg for mercury. Some other elements and their symbols are as follows :

Element	Symbol
Sodium	Na
Silver	Ag
Gold	Au
Copper	Cu
Iron	Fe
Calcium	Ca
Potassium	K
Magnesium	M
Aluminium	Al
Zinc	Zn
Tin	Sn
Lead	Pb
Mercury	Hg
Hydrogen	H
Silicon	Si
Chlorine	Cl
Bromine	Br
Iodine	I
Nitrogen	N
Phosphorus	P

8.12. Atomic Mass

Different elements have different masses. The lightest atom is hydrogen and heaviest naturally occuring is uranium.

For comparing the masses of different atoms John Dalton, an English, scientist suggested the mass of hydrogen atom as a standard measure.

Firstly the masses of other atoms were compared with respect to the mass of hydrogen atom. Later on, oxygen atom was taken as a standard measure.

The mass of atoms expressed in oxygen units was them called the atomic mass.

The standard has now been changed from oxygen to carbon units.

For purposes of a standard the mass of an atom of carbon is taken as 12 and masses of all other atoms are

compared with it. The unit for measuring atomic masses is called the carbon unit which is $\frac{1}{12}$th part of the mass of an atom of carbon.

Chemical element	Symbol	Atomic mass in carbon units
Sulphur	S	32
Magnesium	Mg	24
Calcium	Ca	40
Oxygen	O	16

SUMMARY

1. Substances made up of tiny particles are called molecules.
2. The size of molecules is extremely small.
3. In solids molecules are tightly packed, loosely in liquids and very loosely in gases.
4. Some solids are plastic in nature, some are elastic and some are brittle in nature.
5. Chemical reactions are of two types (A) Decomposition and (B) Combination.
6. Elements are represented by symbols.
7. Molecules can be further divided into the simplest indivisible particles, known as atoms.
8. The mass of a substance depends upon the masses of the atoms present in it.
9. Atoms of different elements have different masses.

QUESTIONS

1. Why are substances solids, liquids and gases ?
2. Why do dust and carbon particles move in air ?
3. Why do ink tables colour water ?
4. Why are short names used to represent things ?
5. Why do some substances spread smell around ?
6. How many known elements make up the world ?
7. Define element and symbol.
8. Differentiate between Elasticity and Plasticity.
9. What is a Chemical Reaction ?
10. What is Decomposition Reaction ? Give two examples.
11. What is Combination Reaction ? Give two examples.
12. Define the following :
    Atom, Electrolysis.

13. Give the symbols of the following elements :

Aluminium,	Carbon,	Magnesium,	Copper
Iron,	Sodium,	Lead,	Potassium
Silver,	Gold.		

14. Fill in the blanks :

(a) Substances are made up of tiny particles called....................

(b) A molecule is made up of two or....................than two....................

(c) Movement of molecules from region of higher concentration to the region of....................concentration is called....................

(d) Movement of water from region of higher water concentration to the region of lower....................concentration is called ....

(e) Molecules have much....................and they get separated widely from one another.

(f) Movement of molecules at random is called....................

(g) The property of a substance to....................its....................after the force ceases to act on it is called....................

(h) Substances which break on applying force are called....................

(i) Chemical reactions in which two or more substances combine together to form a new substance are known as....................

(j) Chemical reactions in which two or more new substances are obtained from one substance, are called....................

9

NATURE AND COMPOSITION OF SUBSTANCES—II

9.1. The law of Conservation of Mass

In an ordinary chemical change the total mass of the substance that reacts is equal to the total mass of the products. This is known as the law of conservation of mass or matter. To put it another way, the total amount of matter at the end of a chemical change is equal to the amount of matter at the beginning of the change. Matter is neither created nor destroyed in a chemical reaction.

If a piece of iron rusts, the mass of the iron oxide formed is equal to the mass of the iron atoms plus the mass of oxygen atoms. There is no gain or loss of mass in the chemical change. Similarly, the total mass of the hydrogen atoms and oxygen atoms produced in the electrolysis of water is equal to the mass of the compound water from which these gases are derived.

Experiment. Dissolve 10 g of silver nitrate ($AgNO_3$) in a conical flask containing 50 ml of water. In another beaker, dissolve 10 g of table salt (NaCl) in 50 ml. of water. Place both on a balance and record their combined weight. Now, add the contents of the test tube to the conical flask. Observe and record any changes that occur. Place both on the balance and once again record their combined weight. Was any mass gained or lost in the chemical change ?

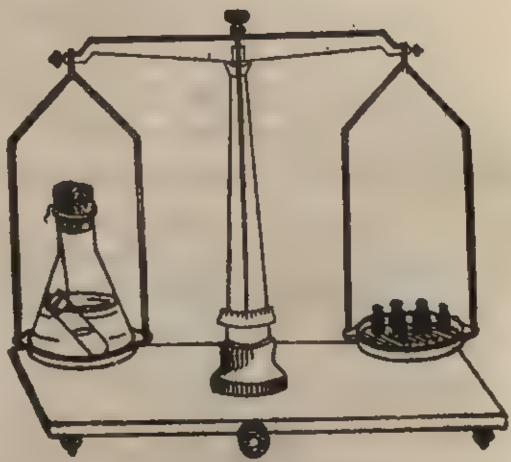


Fig 9 1. The conical flask contains $AgNO_3$ soln. and the beaker cantains NaCl

When an ordinary chemical change occurs, there is never a loss of mass.

When coal burns, only a little ash is left. It appears that most of the matter of coal is destroyed. But it is not so. Actually, there is no loss of matter (reactants). If we could weigh the reactants (coal and oxygen) and

products (all the ash, soot, water vapour and carbon dioxide), we would find that the total mass of the reactants was the same as the mass of the total products.

9.2. Formulae and Valency

In chemistry, the letter or group of letters used to represent an element is called a symbol. A symbol for an element is either one capital letter or two letters, the first of which is capitalized. For example, O is the symbol for oxygen and Hg is the symbol for mercury. In the same manner the molecules of substances are represented by their chemical formulae. In order to achieve at the chemical formulae of a molecule, it is necessary to know :

(*i*) the chemical elements contained in a molecule of the given substance.

(*ii*) the number of atoms of each element present in the molecule.

From electrolysis of water we get 2 hydrogen atoms and one oxygen atom.

A molecule of water ⟶ Two hydrogen atoms + One oxygen atom

Therefore formula of water $= H_2O$.

The ratio by mass in which chemical elements combine to form a compound is always the same. The atoms do not combine with one another in any random ratio. It is on the basis of their characteristic that we express the composition of molecules of substances by means of a formula. Hydrochloric acid is HCl. Similarly H_2 and $CuSO_4$ are the formula for hydrogen and copper sulphate.

Listed below are the formulae of some compounds of hydrogen :

Hydrogen chloride	—HCl
Water	—H_2O
Ammonia	—NH_3
Methane	—CH_4

Here we see that different elements have different powers of combining with hydrogen. The combining power of an atom is also called its *Valency.*

The valency of an element is the number of hydrogen atoms which will combine with or displace the atom of the element.

The formula of a compound tells us the following things :

(*a*) Name of the compound.

(*b*) The components of the compound.

For example, the formula $AgNO_3$ for silver nitrate shows that the compound is made up of three elements silver, nitrogen and oxygen.

(*c*) The ratio in which atoms are combined. For example the formula easily shows that calcium and chloride are combined in the ratio of 1 : 2.

(*d*) The atomic masses of the constituent element. For example, the proportion of hydrogen and oxygen

by mass in H_2O is 1 : 8.

The molecular mass of MgO is=40

$$Mg + O = MgO$$

atomic mass = 24 + 16=40 molecula. mass.

9.3. Finding the Valency from formula

In the molecule of CO_2, the two atoms of oxygen give a total valency of 4 which is balanced by the valency exhibited by an atom of carbon. So carbon has valency 4.

In NaCl (Sodium chloride) one atom of sodium combines with one atom of chlorine and valency of each sodium and chlorine is 1.

Iron has valency 3 in Iron oxide (Fe_2O_3). In another compound of Iron FeO (Ferrous Oxide) Iron shows a valency of 2. So Iron has two valencies 2 and 3.

Valency 1	Valency 2
Ammonium—NH_4	Carbonate—CO_3
Hydroxide —OH	Sulphate —SO_4
Nitrate —NO_3	Sulphite —SO_3
Hydrogen —H	Sodium —Na

9.4. Chemical equation

Hydrogen + Oxygen ⟶ Water

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Chemists use an equation to represent chemical changes. An equation is a type of shorthand that describes the atoms and their rearrangement in a chemical reaction. In an equation + read as 'Plus' and ⟶ read as 'yields' or 'produces'.

Iron + sulphur → Iron sulphide

water → Hydrogen + Oxygen

The subtance to the left of the yields sign in the equation are the starting substances or reactants. The substances to the right of the yields sign are the resulting substances or products.

To change a word equation to a much shorter form, the chemist substitutes formulas and symbols for words. The shorter equation is called a *chemical equation.*

Word equation—

Iron + sulphur ⟶ Iron sulphide

Chemical equation—

$$Fe + S \longrightarrow FeS$$

A chemical equation must be balanced. The number of atoms on the left side of the arrow must equal the number of the same atoms on the right side of the arrow. In Iron and sulphur equation—one atom of Iron and one atom of sulphur appear on the side of the yields sign. Therefore, the chemical equation for this reaction between Iron and sulphur is balanced.

The following chemical equation shows how an unbalanced chemical equation may be balanced

$$H_2 + O_2 \longrightarrow H_2O$$

2 Hydrogen atoms	2 Hydrogen atoms
+	+
2 Oxygen atoms	1 Oxygen atom

Compare the number and kinds of atoms in this chemical equation.

There are 2 Hydrogen atoms on

both sides of this equation. But the equation remains unbalanced because there are 2 oxygen atoms on the left side and only 1 oxygen atom on the right side of the arrow. To balance this equation, $2H_2$ are needed and also $2H_2O$.

Balanced chemical equation—

$$2H_2 + O_2 \rightarrow 2H_2O$$

$2 \times 2 = 4$	$2 \times 2 = 4$
Hydrogen atoms	Hydrogen atoms
+	$2 \times 1 = 2$
2 Oxygen atoms	Oxygen atoms

This equation is balanced because there is an equal number of the same atoms on both sides of the equation. Numbers added to balance an equation are coefficients.

Never change a subscription or a formula to balance an equation. Changing a subscript changes the substance. Changing the coefficients changes only the number of molecules of the same substance taking part in the reaction. The balanced chemical equation for the production of water is read 'Two molecules of hydrogen plus one molecule of oxygen yields two molecules of water'.

Another example—

Word equation—

Iron + Oxygen ⟶ Iron oxide

Chemical Equations

$Fe + O_2 \longrightarrow Fe_2O_3$

$CaCO_3 + HCl \longrightarrow CaCl_2 + H_2O + CO$

$Zn + HCl \longrightarrow ZnCl_2 + H_2 \uparrow$

$Pb(NO_3)_2 \longrightarrow PbO + NO_2 + CO_2$

$Al_2(SO_4)_3 + Ca(OH)_2 \longrightarrow Al(OH)_3 \downarrow + CaSO_4 \downarrow$

Balanced Chemical Equations

$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

$CaCO_3 + 2HCl \longrightarrow ZnCl_2 + H_2O + CO_2 \uparrow$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2 \uparrow$

$2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 \uparrow + O_2 \uparrow$

$Al_2(SO_4)_3 + 3Ca(OH)_2 \longrightarrow 2\ Al(OH)_3 \uparrow + 3CaSO_4 \uparrow$

Use these steps to write chemical equations—

(1) Write a word equation that shows the starting substance and the end products.

(2) Write a chemical equation using symbols and formulas.

(3) If necessary, add coefficients to balance the equation.

(4) Write an upward pointing arrow beside the formula for a product if you know it is a gas.

Examples—

Water ⟶ Hydrogen + Oxygen

$H_2O \longrightarrow H_2 + O_2 \uparrow$

$2H_2O \longrightarrow 2H_2 + O_2 \uparrow$

$Zn + HCl \rightarrow ZnCl_2 + H_2 \uparrow$

$Zn + 2HCl \rightarrow ZnCl_2 + H_2 \uparrow$

SUMMARY

1. Atoms can neither be created nor destroyed in a chemical reaction.

2. During chemical reactions, the masses of reactants and the reaction products remain the same.

3. Chemical elements are represented by these symbols.

4. The molecules of substances are represented by their chemical formula.

5. The ability of an atom of a chemical element to unite with a definite number of atom of other elements is known as valency.

6. The magnitude of valency is expressed by a whole number.

7. The mode of representing a chemical reaction with the help of formulae is called chemical equation.

8. Chemical equations are written in the form of mathematical equations.

9. This represents the reactants and reaction products by using symbols and formula.

10. This also represents the amount of the reactants and reaction products in the form of mass or volume.

QUESTIONS

1. State the law of conservation of mass.

2. Describe an experiment to illustrate the law of conservation of mass.

3. Why do we use shorthand language ?

4. Why do we see chemical formulae of the various constituents instead of their full names on the labels of medicine bottles ?

5. What do + and → represent in a chemical equation.

6. Define reactant, product and chemical equation ?

7. How is a chemical equation balanced ?

8. What steps are used to write a balanced chemical equation ?

9. Write down the formulas for the
   (*i*) Hydroxides (*ii*) Copper (*iii*) Ammonium
   (*iv*) Sulphates (*v*) Carbonates.

10. Write down the formula for ammonium chloride and ammonium nitrate.

11. Write each of the following as a balanced chemical equation.
   (*a*) carbon + oxygen ⟶ carbon dioxide
   (*b*) sulphur + oxygen ⟶ sulphur dioxide
   (*c*) sodium + chlorine ⟶ sodium chloride
   (*d*) Hydrogen + chlorine ⟶ hydrogen chloride.

12. What is valency ? Find the valencies from the following formulae :

$$CO_2, SO_3, N_2O_5, Fe_2O_3, PCl_5.$$

13. (*a*) What is a chemical formula ?

    (*b*) What does a chemical formula indicate ?

14. Balance the following equations :

    1. $Fe+O_2 \longrightarrow Fe_2O_3$
    2. $Al+HCl \longrightarrow AlCl_3+H_2$
    3. $Mg+H_2O \longrightarrow Mg(OH)_2$
    4. $Hg+O_2 \longrightarrow HgO$
    5. $Ag_2O \longrightarrow Ag+O_2$.

10

AIR

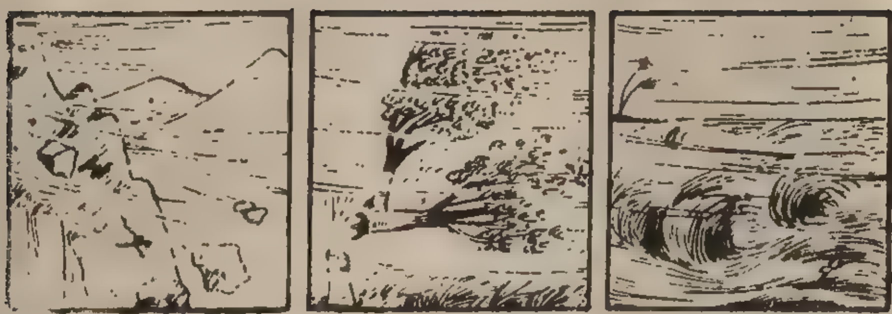


Fig. 10.1. Moving Air

10.1. Air

Air is all round us. Although air is invisible, there are many ways in which it can be detected. If you hold your fingers in front of your nose, you can sense air movement as you exhale. Moving air can make a tree's branches sway back and forth. And the force of air can push a balloon filled with helium high up into the sky. We live at the bottom of an ocean of air which surrounds the earth.

10.2. Composition of the Atmosphere

The atmosphere is the air which surrounds the earth and extends about 960 km. above its surface.

Invert a glass bottle and press it into the water inside a big jar. Does the water fill the bottle ?

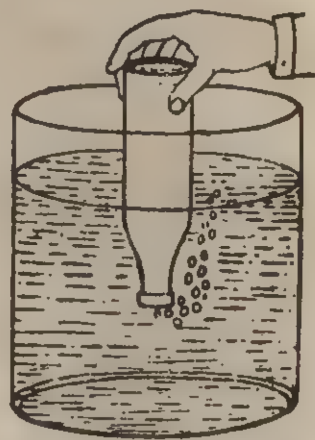


Fig. 10.2. Air bubbles rush out of an empty bottle when dipped in water

Air occupies space and has weight. Air is a mixture of gases, fine dust particles and water vapour. Its gases are mostly nitrogen and oxygen. About 78 percent of air is nitrogen (N_2) and about 21 percent is oxygen (O_2), making a total of 99 percent.

The remaining 1 percent of the air is argon (Ar), carbon dioxide (CO_2) and minute amounts of other gases.

TABLE 1

Gas	*Percent by Volume*	*Minute Amount*	
Nitrogen	78·09	Neon	Xenon
Oxygen	20·95	Helium	Radon
Argon	0·93	Kypton	Water Vapour
Carbon dioxide	0·03	Hydrogen	

The outer limit of the air surrounding the earth is indefinite. However, air is very dense near the surface of the earth and becomes less dense with increased altitude. This occurs because the force of gravity, the major factor that prevents the atmosphere from drifting into space, is stronger near the earth's surface.

The portion of the atmosphere about 12 km. above the earth is called the Troposphere. Almost all weather activity occurs in this layer. As you leave the earth's surface and go higher in the Troposphere, the temperature, continually decreases. The decrease is fairly constant.

The upper boundary of the troposphere is called the tropopause. Beyond the tropopause is the stratosphere. The upper limit of the stratosphere is called the stratopause. Beyond it, is an extremely thin layer of atmosphere known as the ionosphere. It is named ionosphere because it contains a great concentration of electrically charged atoms called ions. The composition of the ionosphere is also unique because it is rich in a form of oxygen called ozone (O_3).

The ionosphere is a great aid to radio communication. Radar is one kind of radio wave which passes through the ionosphere.

Weather is the condition of the atmosphere at a particular time.

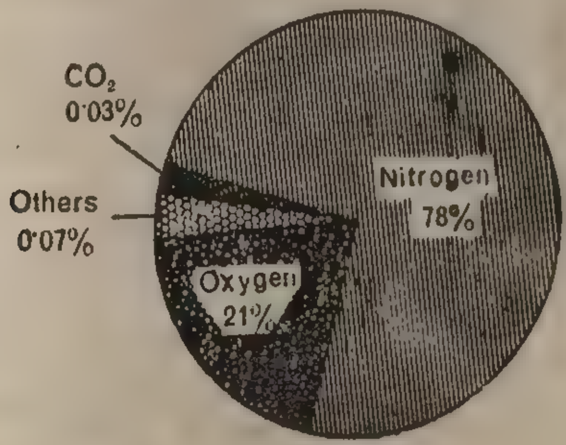


Fig. 10.3. Composition of Air.

Climate is the average weather over a long period of time.

The scientific study of weather and climate is called meteorology.

10.3. Oxygen

Oxyen is the most abundant of all the elements. It is found in the air, the sea and the land. In the air, oxygen is mostly present as the uncombined element, occupying one-fifth of the total volume. Some oxygen is dissolved in the water of the sea, providing fish and other organisms in the sea with one of their means of life.

The Swedish chemist, Scheels first prepared oxygen in 1771 by heating mercuric oxide. Priestley, the well known chemist of England, also prepared this gas. It was left to the French scientist, Lavoisier to study its properties and give it the name 'oxine' (oxygen). The symbol of oxygen is O and its molecular formula is O_2. Its atomic mass is 16.

Fig. 10.4. Karl Wilhelm Scheels (1742—86) Scheel's experiment on air and combustion led him to the discovery of oxygen in 1772.

10.4. Preparation of oxygen

Green plants are the source of oxygen present in our atmosphere.

Experiment. Collect some water plants and keep them in a beaker. Fill the beaker $\frac{3}{4}$th with water. Invert the funnel over the beaker containing the plant. Take a small test tube completely filled with water and invert it over the stem of the funnel. Expose the whole apparatus to sunlight.

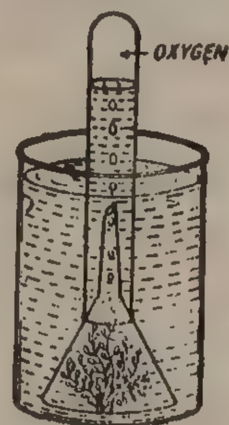


Fig. 10 5. Oxygen from green water plants

After a few hours, you will observe bubbles of gas rising with the test tube and collecting at the top. Put a thumb at the mouth of the test tube while it is inside water and remove the test tube carefully. Now introduce a glowing match stick into the test tube. It will burst into a flame due to the presence of oxygen in the test tube.

1. Laboratory Method. In the laboratory, oxygen gas can be prepared by heating Potassium chlorate in a

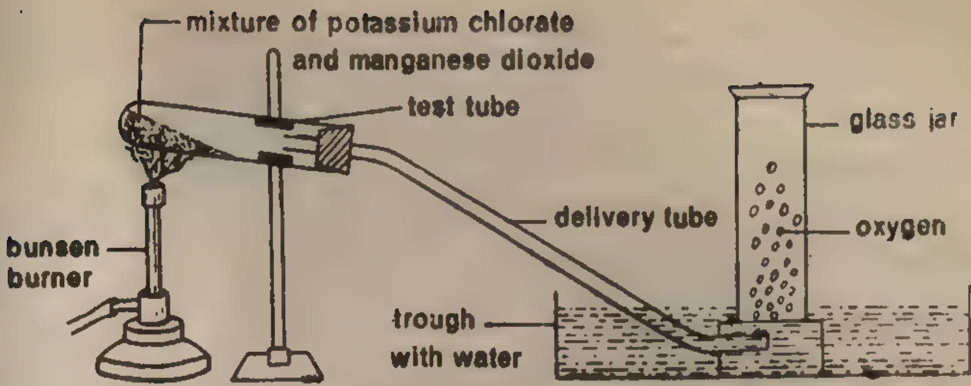


Fig. 10.6. Preparation of Oxygen by heating a mixture of Potassium chlorate and Manganese dioxide

hard glass test tube. If Potassium chlorate is heated alone, it melts and then decomposes. When manganese dioxide is added to Potassium chlorate (about ⅛th of the total weight being Manganese dioxide), oxygen is given off at a much lower temperature, 200°C instead of about 400°C and at a steady rate.

The reaction is

Potassium chlorate + Manganese dioxide $\xrightarrow{\text{Heat}}$

$\xrightarrow{\text{Heat}}$ Potassium chloride + oxygen + Manganese dioxide

$$2KClO_3 + MnO_2 \xrightarrow{\text{heat}} 2KCl + 3O_2 + MnO_2.$$

Reaction goes faster in the presence of Manganese dioxide.

Collect the gas in a gas jar by downward displacement of water. In this method MnO_2 acts as a catalyst.

'A catalyst is a substance which increases the rate of a chemical change without itself undergoing any permanent chemical change.'

Copper oxide and ferric oxide will also help $KClO_3$ to give up its oxygen more rapidly. These subtances are known as catalysts.

10.5. Properties of Oxygen

Physical properties. Collect the gas in several gas jars and study the following properties (*i*) colour (*ii*) smell or odour (*iii*) solubility in water.

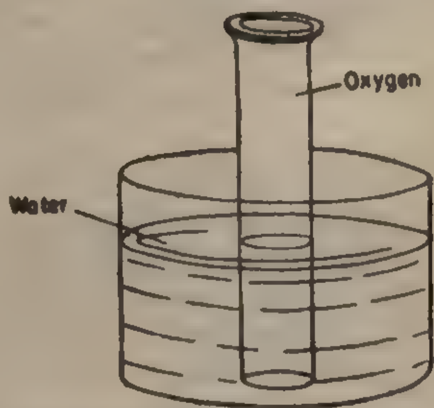


Fig. 10.7. Oxygen is very slightly soluble in water

We find that oxygen is colourless. odourless gas. It is slightly heavier than air and is slightly soluble in

water. Aquatic plants and animals can live in water because of this property.

Chemical properties :

1. Warm some sulphur in a deflagrating spoon until it begins to

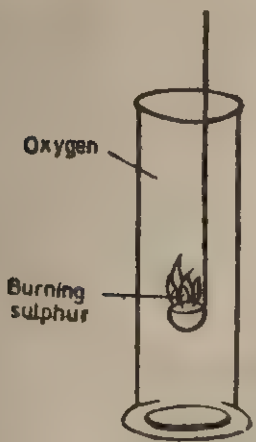


Fig. 10.8. Burning of sulphur in oxygen

burn and then plunge the burning sulphur into a gas jar of oxygen. We observe that sulphur burns with a bright blue flame giving out a pungent smell.

$$S+O_2 \rightarrow SO_2$$

When the reaction ceases, add a little water, put back the glass covers and shake the jar and its contents. Add a few drops of neutral litmus solution and notice the colour change if any.

2. Put a small piece of phosphorus in a deflagrating spoon into a gas jar of oxygen. What happens? The other steps are the same as those described for sulphur

$$P_4+5O_2 \rightarrow P_4O_{10}.$$

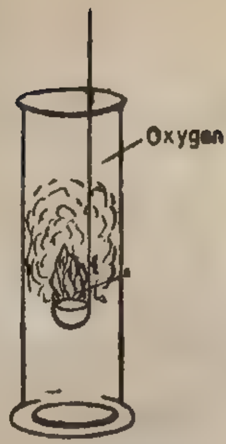


Fig. 10.9. Burning of phosphorus in oxygen.

3. Place a piece of charcoal on a deflagrating spoon. Heat it red hot. When the charcoal starts glowing introduce it into a gas jar of oxygen. Charcoal (carbon) burns more vigorously in oxygen liberating heat.

$$C+O_2 \rightarrow CO_2+\text{heat}$$

Add a little lime water into the jar and shake. You will observe that it becomes milky.

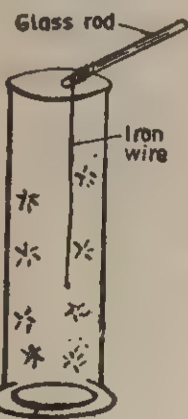


Fig. 10.10. Burning of iron in oxygen

4. Heat a small piece of sodium in a deflagrating spoon until it melts

and then plunge it into a gas jar of oxygen.

$$2Na+O_2 \rightarrow Na_2O_2$$

5. As a source of iron, we use steel wool and heat it to redness before plunging it into a gas jar of oxygen.

$$3Fe+2O_2 \rightarrow Fe_3O_4$$

Sodium and iron burn brightly in oxygen.

6. Do the same thing with a piece of Calcium and Magnesium and note the colour of the flame.

$$2Ca + O_2 \rightarrow 2CaO$$
$$2Mg + O_2 \rightarrow 2MgO$$

10.6.

Solutions of the products of burning *i.e.*, solutions of the oxides of the elements, turn the neutral litmus red or blue. No change is observed in the case of iron because the oxide in this case is insoluble in water. The non-metal oxide solutions turn litmus red and the metal oxide solutions turn litmus blue.

Litmus is known as an indicator. When it turns red it indicates an acidic solution and when it turns blue it indicates an alkaline solution.

Metal oxides, when soluble, give alkaline solutions. Non-metal oxides when soluble, give acidic solutions. For metal oxides whether soluble or not, the term basic oxide is used. Non-metal oxides which give acidic solutions are known as acidic oxides.

10.7. Uses of Oxygen :

Oxygen is very important for all living beings as it is needed for respiration. Without oxygen, life on the earth would have been impossible.

Fish and other aquatic animals and plants breathe oxygen that is dissolved in water. Oxygen is essential for burning oxy-acetylene flame that is used for welding and cutting metallic plates. It is also used in industry and hospitals.

Combustion of fuels produces heat which may be converted into mechanical, electrical and other types of energy.

Oxygen also finds wide use in many branches of chemical industry, like the production of acids and other important chemicals.

Fig. 10.11. Welding by means of oxy-acetylene flame

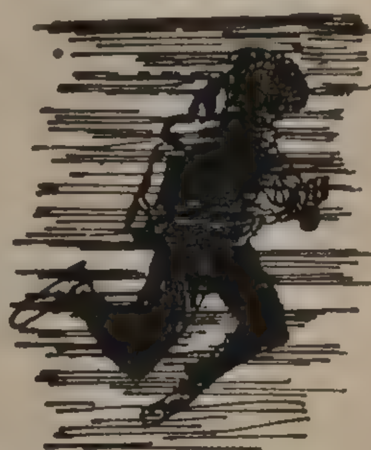


Fig. 10.12. A diver

There are situations in which the natural supply of oxygen for breathing.

Fig. 10.13. A patient under the oxygen tent

is not enough. In these situations men and women carry supplies of oxygen with them in cylinders—mountaineers at high altitudes, astronauts, submariners, divers. Certain illnesses result in breathing difficulties and patients are given oxygen to breathe, either through a mask or being put in an oxygen tent.

Air Pollution :

Air also contains water vapour. Any other substance found in air can be considered a pollutant, that is, waste material which is harmful to well being. Most offence is caused by fires used for cooking and heating. These fill the air with smoke, ash and sulphur-dioxide. The exhaust of cars sends out oxides of nitrogen, poisonous carbondioxide, carbon monoxide, and poisonous lead compounds. Waste materials from factories may pollute the atmosphere. After the Industrial Revolution many of these pollutants were allowed to pollute the atmosphere without any control for their effects. Men are more conscious of their environments at the present time, and much more effort is made to control the escape of anything which might pollute the atmosphere.

SUMMARY

1. Air is present everywhere around us.

2. It is colourless, odourless and tasteless and is a mixture of different gases.

3. Air is denser near the sea-level and becomes lighter as the height from sea-level increases.

4. Oxygen is the most important constituent of air.

5. In nature it is produced by green plants.

6. It can be prepared in the laboratory by heating Potassium chlorate ($KClO_3$), Potassium Permanganate ($KMnO_4$) and Potassium-nitrate (KNO_3).

7. It is also colourless, odourless, tasteless and slightly soluble in water.

8. It is a supporter of combustion.

9. Carbon, Magnesium, sodium, sulphur etc., burn in oxygen and their oxides are formed.

10. The oxides of carbon and sulphur are acidic in nature. The oxides of sodium and magnesium are basic in nature.

11. The oxygen present in air, in presence of little moisture, reacts with iron to produce rust (iron oxide) and rusting is prevented by coating the surface of iron with suitable paints.

12. Fish and other aquatic animals and plants breathe oxygen which is in dissolved state in water.

13. It is also used in industry and hospitals.

14. It is essential for burning.

15. Oxyacetylene flame is used for welding and cutting metallic plants.

16. Air can be polluted by smoke, ash and sulphur dioxide.

QUESTIONS

1. Why is air necessary for burning wood, coal etc. ?

2. Give the laboratory method for the preparation of oxygen gas. Why do we use MnO_2 for this purpose ?

3. Why do we need extra oxygen supply at high altitudes ?

4. What are the two essential points about a catalyst ?

5. Name three abundantly occuring substances which contain oxygen ?

6. Explain with examples, the meaning of acidic and basic oxides. How would you obtain an alkaline solution from the burning of a suitable substance ?

7. Explain the use of oxygen in (*a*) hospitals (*b*) mountaineering.

8. Explain the following terms :

(*i*) Troposphere (*ii*) Stratosphere
(*iii*) Ionosphere (*iv*) Catalyst.

9. What are the constant and variable constituents of air. List the local impurities present in air.

10. Sort out the acidic oxides and basic oxides from the list of oxides given below :

Fe_2O_3, Na_2O, PbO, CO_2, SO_2, P_2O_5, MgO, FeO

11. What are the harms which polluted air causes to health ?

12. Fill in the blanks :

(*a*) Atomic weight of oxygen is................

(*b*) Molecular weight of oxygen is................

(*c*) Chemical symbol of oxygen is................

(*d*) Molecular formula of oxygen is................

(*e*) The................Chemist................first prepared oxygen in 1771.

(*f*) ....studied the properties of oxygen.

11

WATER

11.1. General

Have you ever been without water for a long period of time? How did you feel? If you have ever kept a pet, you are probably aware of the importance of water to life.

Water is an inorganic compound. It does not contain carbon and does not yield energy in the body. However, it is vital in a number of ways. About sixty or seventy percent of our body is water. Water is one of the main ingredients in protoplasm. About 92 percent of liquid blood plasma is water.

Water is also used in digestion to chemically split complex food molecules into simpler molecules. Water is the main solvent in the body. For instance, digested foods are dissolved in water when they are absorbed by the digestive tract. In the sweat glands of the skin and in the kidneys uric acid is excreted and dissolved in water before it is passed from the body. The water that evaporates as perspiration from the surface of the body helps to regulate body temperature. The rate at which water evaporates from the body surface depends upon the temperature of the air and the relative humidity.

11.2. Water in Nature

Water is one of the most abundant materials available to man. Man can obtain water from a variety of sources. It fills the seas, rivers and lakes, which cover more than 3/4 of the earth's surface, some rain water soaks and percolates in the ground, making the soil wet. As more rain falls, the percolated water moves down the soil until it meets a hard rock and the water is known as ground water. It collects underground and begins to move towards an opening in the ground. When it finds an opening, it comes out and is called a spring. Springs feed wells, lakes and some rivers.

In the atmosphere, water is present in huge quantities as vapours, mist or cloud.

Water from different sources has different properties.

All the foods you eat contain water. Some are especially rich in this nutrient. Vegetables and fruits have a high water content. You obtain water by drinking it and by drinking

Human body is 70 per cent water. Melons and lettuce contain up to 95 per cent water

Eggs, meat and potato contain about 75 per cent water.

Fig. 11.1. Percentage of water in human body and some food substances

milk and juices. Some water is produced in the oxidation of food within the cells, as shown in the equation below :

Glucose + Oxygen → Carbon dioxide + Water

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

The percentages of water by mass present in some of the foodstuffs are given below :

Cucumber—95% , Turnip—88% ,
Meat —75% , Potato—75% ,
Egg —73%.

Some common substances apparently look dry such as dry splinters of wood, dry pulses, a few pieces of blotting paper, etc. If we heat these substances carefully without letting the contents char in the test tube, we will notice water droplets on the outer parts of the test tube.

11.3. Solutions

A solution is composed of two or more substances in which the particles of the substances are uniformly distributed throughout. No particle in a solution is larger than a molecule. Salt in water, iodine in alcohol, and oxygen in water are the examples of solution. Solution is a physical change, no chemical change takes place when a substance dissolves.

Sugar dissolves in water to form a sugar solution. The sugar molecules move to all parts of the water and mix with the water molecules. The same sweetness may be tasted in all parts of the solution.

The substance that is dissolved in a solution (sugar) is called the solute. The substance that dissolves the solute (water) is called the

solvent.

solute + solvent → solution

A solute generally lowers the freezing point of a solvent in which it is dissolved. For this reason, anti-freeze (solute) may be added to water (solvent) in automobile radiators. However the addition of solute to a solvent raises the boiling point. Table 1 gives some common examples of solutions.

Suspensions

A mixture of solid and liquid material does not always produce a true solution. Frequently, when a solid and a liquid are mixed, a suspension is formed. A suspension is a state of a substance in which its particles are mixed but not dissolved. Sometimes the particles in a suspension are microscopic. Sand and oil do not dissolve. Water, on being shaken with sand or oil becomes turbid due to the fine solid particles of sand or minute droplets of oil which remain suspended in water. Such a mixture is called a suspension.

11.4. Solubility

A solid dissolved in a liquid is the most common solution combination. The most common liquid solvent is water. Some substances dissolve readily in water, while others do not. The substance that does not dissolve in water is said to be insoluble in water.

The amount of a solid that may be dissolved in water depends largely upon the nature of the solid and the temperature of the water. For example, more table salt can be dissolved in water than copper sulphate ($CuSO_4$).

The solubility of a solute is the

TABLE 1

	Solute	*Solvent*	*Common Example*
1.	Gas	Gas	Deep-sea divers gas, Helium in oxygen
2.	Liquid	Gas	Open perfume bottle
3.	Solid	Gas	Naphthalene in oil
4.	Gas	Liquid	Welding—acetylene in acetone
5.	Liquid	Liquid	Alcohol in water
6.	Solid	Liquid	Sea water—salt in water
7.	Gas	Solid	Gas stone lighter—hydrogen in palladium
8.	Liquid	Solid	Dental mercury in cadmium
9.	Solid	Solid	Ornaments—silver in gold.

amount of the solute that can be dissolved in a given amount of a certain solvent.

When a solvent has dissolved the maximum amount of solute at a given temperature, it is said to be a *saturated solution.*

If additional solute is added to a saturated solution, the solute does not dissolve. It sinks to the bottom of the solution where it remains.

The solution in which some more quantity of the solute can be dissolved at a fixed temperature is called an *unsaturated solution.*

A *super saturated* solution contains more dissolved solute that the amount it would normally take to saturate it. A super saturated solution is often prepared by cooling a hot saturated solution very carefully to avoid separation of the excess solute.

10.5. Solubility of Gases

The solubility of gases in liquids is affected by the nature of the gas, temperature of the gas, and the pressure of the gas. Some gases are more soluble than others.

A glass of the tap water often appears milky. This appearance is caused by tiny air bubbles in the water produced when some dissolved air is forced out from the water as it is heated. Air is a mixture of gases. As the water warms, air is released from solution and tiny bubbles are formed. The release of air bubbles from warm water shows that gases are less soluble in warm water than in cold water.

If a large amount of solute is present per unit volume, the solution is a *concentrated solution.* If only a small amount of solute is present per unit volume, the solution is a *dilute solution.*

11.6. Composition of Water

During the electrolysis of water, oxygen and hydrogen gases are liberated. The composition of water is

Hydrogen	+	Oxygen	→	Water
2H	+	O_2	→	$2H_2O$
2 volumes		1 volume		2 volumes

Thus 2 volumes of hydrogen need 1 volume of oxygen to form 2 volumes of water. That is, the ratio of oxygen to hydrogen by volume in water 1 : 2.

The mass of hydrogen atom is 1 and that of oxygen is 16. Thus the ratio of hydrogen to oxygen in water by mass is 2 : 16 *i.e.* 1 : 8.

The ratio of hydrogen to oxygen remains constant in any sample of water.

11.7. Hydrogen

It was seen that hydrogen could be liberated from water (or steam) by the action of metals. Despite the abundance of water, its structure was not known. Just over 300 years ago the existence of hydrogen was suspected when Robert Boyle saw bubbles of a gas form after iron was placed in sulphuric acid. About a century later, Henry Cavendish used

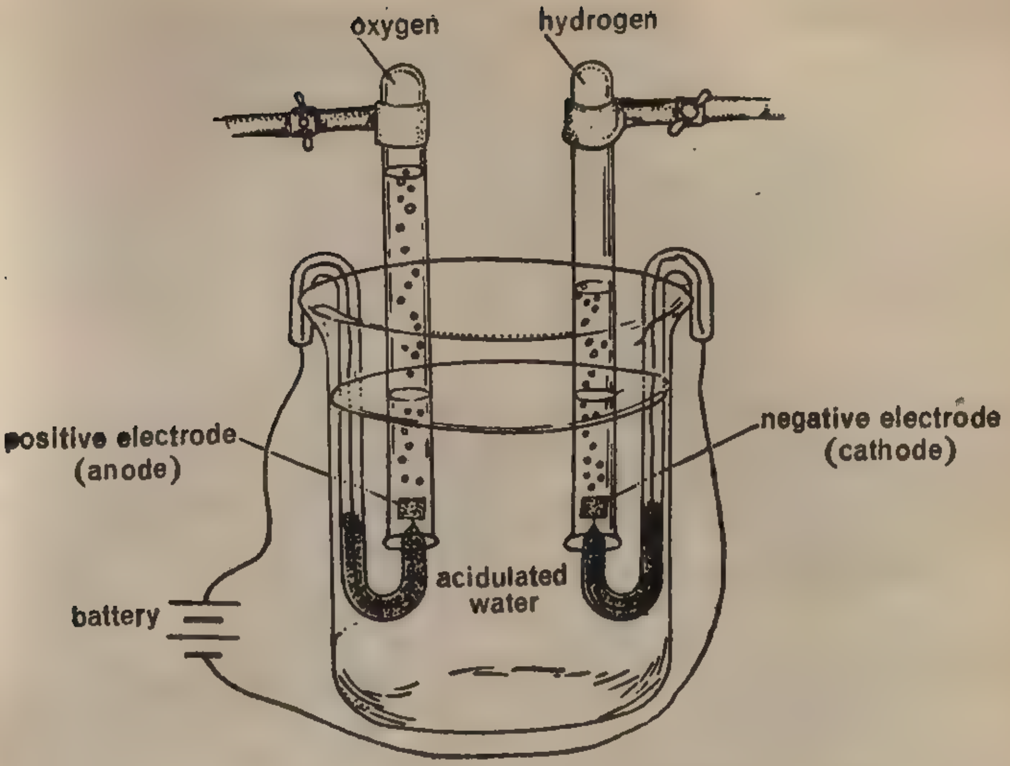


Fig. 11.2. Composition of water

the action of dilute sulphuric acid on metals to prepare hydrogen. It was Cavendish who discovered that hydrogen burns and in 1781 he proved that water is the only product obtained on the burning hydrogen in air.

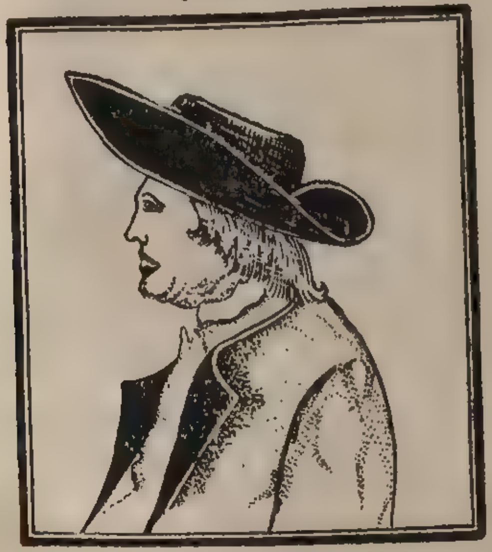


Fig. 11.3. Henry Cavendish (1731—1810)

11.8. Preparation of Hydrogen

The action of metals on water is either too violent so that hydrogen cannot be collected, or it is too slow if a reasonably large quantity of hydrogen is required. So in the laboratory, it is usual to use easier method, *i.e.*, action of dilute sulphuric acid or dilute hydrochloric acid on metals.

Laboratory Method

Take a few pieces of granulated zinc in a Woolfe's bottle. Add dilute

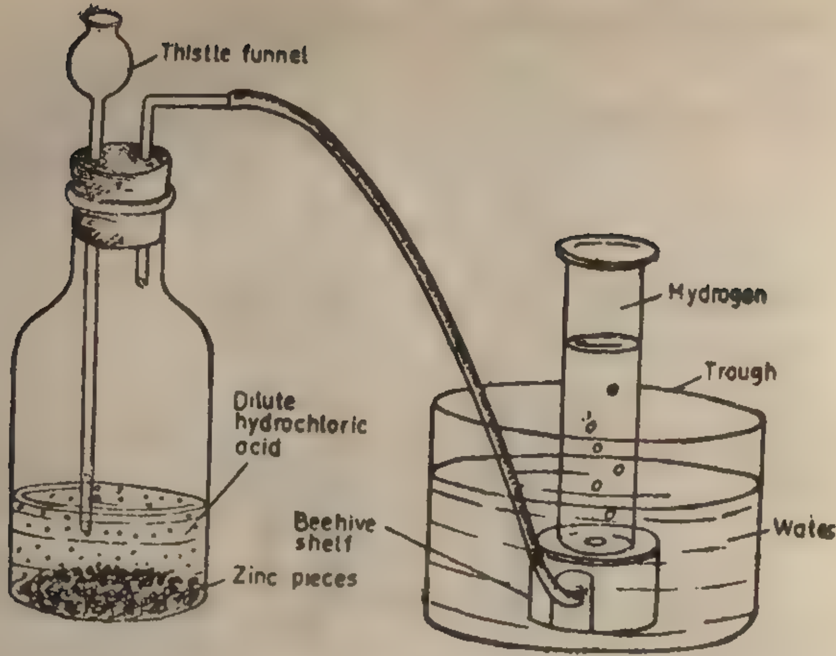


Fig. 11.4. Preparation of hydrogen by the action of zinc on dilute hydrochloric acid

hydrochloric acid through the thistle funnel. A vigorous reaction takes place with the evolution of a gas.

Zinc + dilute hydrochloric acid → zinc chloride + Hydrogen

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Now collect the gas by the downward displacement of water as shown in the Fig. 11.4.

11.9. Physical Properties

Collect the gas in several gas jars and study these properties—(*i*) colour (*ii*) smell or (*iii*) solubility.

Hydrogen is a colourless gas. It is very slightly soluble in water and that is why we collect it by the downward displacement of water.

(*iv*) It is less dense than air.

To show that hydrogen is less dense than air.

Place a dry test tube containing air

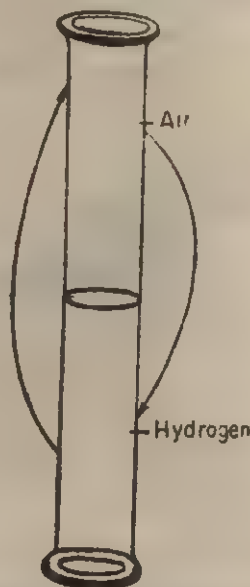


Fig. 11.5. Hydrogen escapes upwards showing that it is lighter than air.

over a tube of hydrogen as shown in the Fig. 11.5. After a few seconds test the upper tube with a burning match stick. The 'pop' sound shows that hydrogen has flowed upwards.

It is the lightest gas known.

(*v*) It can be liquefied by the application of low temperature and high pressure.

(*vi*) Hydrogen burns but does not support burning.

11.10. Chemical Properties

(1) Bring a burning piece of wood at the mouth of a gas jar filled with hydrogen. Hydrogen catches fire and burns with a blue flame forming water.

$$2H_2 + O_2 \rightarrow 2H_2O$$

(*ii*) **Reaction of hydrogen with metal oxides.**

Carry out the experiment with

(*i*) Copper oxide (CuO)

(*ii*) Lead oxide (PbO).

Experiment. Put some copper oxide in a test tube. Pass hydrogen gas over it. Heat the copper oxide gently and observe any changes which take place.

When hydrogen gas is passed over the heated black copper oxide, it removes oxygen from the copper oxide and a reddish substance is formed. The reddish substance is metallic copper

Copper oxide + Hydrogen → Copper + Water

$$CuO + H_2 \rightarrow Cu + H_2O$$

Similarly, when hydrogen is passed over heated lead oxide, water and

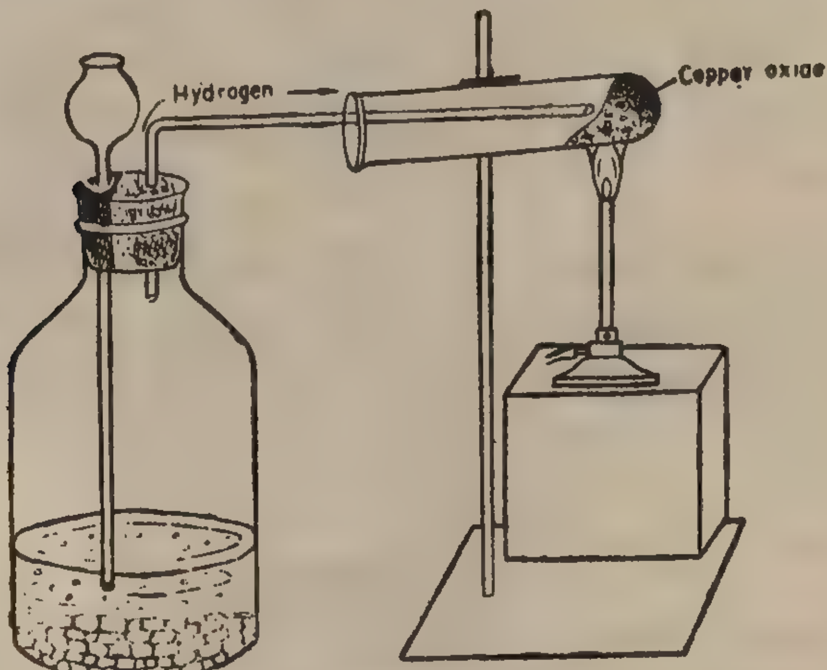


Fig. 11.6. Hydrogen reduces heated copper oxide to copper metal.

lead are formed.

$$\text{Hydrogen} + \text{lead oxide} \rightarrow \text{Water} + \text{lead}$$

$$H_2O + PbO \rightarrow H_2O + Pb$$

11.11. Uses of Hydrogen

All acids contain hydrogen. It is also present in many minerals, vegetable, animal organisms, coal, oil, wood, petroleum and natural inflammable gases. It is present in all foods, such as starch, fat, seed oils, sugar and proteins.

Most of the hydrogen which is manufactured is combined with nitrogen to form the (NH_3) ammonia gas. This is used to manufacture fertilizers, dye stuffs explosives and other useful compounds.

Hydrogen is also used for making vanaspati and margarine from vegetable oils.

On account of its low density hydrogen is used to fill balloons. These are not just toys of children but the balloons are used by scientists to study the weather.

Hydrogen produces much heat when it burns. This property is used in making oxy-hydrogen torch which can attain a temperature of about 4000°C. This torch is used for cutting and welding metals which require very high temperature.

It is often used as a reducing agent for the extraction of metals from their oxides.

11.12. Oxidation and Reduction

Consider the reaction of copper oxide with hydrogen. Oxygen is removed from copper oxide by hydrogen. This process is known as *reduction* and hydrogen which brings about the reduction is known as *reducing agent.*

Oxygen of copper oxide has combined with hydrogen and formed water. The addition of oxygen to hydrogen is called oxidation. The substance which tránsfers oxygen to another substance or removes hydrogen from that substance is called an oxidizing agent.

Reduced

$$CuO \qquad + H_2 \qquad Cu + H_2O$$

Oxidized

Thus 'oxidation' is a process in which oxygen is added or hydrogen is removed. On the other hand, 'reduction' is a process in which hydrogen is added or oxygen is removed.

The substance which transfers oxygen to another substance or removes hydrogen from that substance is called an 'oxidizing agent'. On the other hand, the substance which transfers hydrogen to another substance or removes oxygen from that substance is known as 'reducing agent'.

Oxidation is one of the most important processes that occur in our bodies.

SUMMARY

1. Water is present in all food-stuffs and in living beings.

2. It has great ability to dissolve many substances.

3. Some solid substances dissolve in water to form solutions.

4. Gases also dissolve in water.

5. Some gases are soluble in water ; some are not.

6. Similarly some liquids are completely mixed with water, while some are not.

7. Solubility of substances in water increases with temperature.

8. Hydrogen, which is a constituent of water, can be prepared in the laboratory by the reaction of dilute HCl on Zn or dilute H_2SO_4 on Zn.

9. It is colourless, odourless gas, slightly soluble in water.

10. It is the lightest gas.

11. Oxidation is a process in which oxygen is added to an element or hydrogen is removed from any of its compounds.

12. Reduction is a process in which hydrogen is added to an element or oxygen is removed from any of its compounds.

13. Hydrogen is used for the preparation of vanaspati ghee, margarine ammonia gas, fertilizers, etc.

14. It is used in oxy-hydrogen torch, which is used for welding and cutting metals.

15. It is also used for filling balloons used by children and also for weather observations.

QUESTIONS

1. Why do you feel uncomfortable on a hot humid day ?

2. State the uses of water in your body ?

3. How is water formed inside your body ?

4. Define solution, solute and solvent. Give one example of each of these terms.

5. How do fish and water plants survive in water ?

6. Metals react with dilute HCl liberating hydrogen. Which metal would you use in the laboratory for the preparation of hydrogen ? Give reason for your choice.

7. What are the physical properties of hydrogen ?

8. Explain the uses of hydrogen.

9. Write the word equation for the reduction of lead oxide with hydrogen.

10. Explain what is meant by each of the following and give one example of each :

(*a*) Oxidation, (*b*) Reduction, (*c*) Oxidizing agent, (*d*) Reducing agent.

11. Write a few sentences about the distribution of water in Nature.

12. Complete the following equations :

$$PbO + H_2 \rightarrow$$
$$CuO + H_2 \rightarrow$$
$$Zn + HCl \rightarrow$$
$$Fe + H_2O \rightarrow$$
$$Al + MnO_2 \rightarrow$$

13. Fill in the blanks :

(*a*) The mixture with suspended particles of fine solid particles or minute droplets is called...............

(*b*) Water solutions are called...............

(*c*) Water is a...............

(*d*) Solid particles in a solution are called...............

(*e*) A solution in which a given...............stops...............further at a fixed temperature is called...............

(*f*) Chemical symbol of Hydrogen is...............

(*g*) The addition of oxygen to hydrogen is called...............

(*h*) The removalof oxygen from water is called...............

□

12

ACIDS, BASES AND SALTS

12.1. Oxides

When elements are burnt in oxygen, oxides are formed.

For example when carbon, sulphur, magnesium and sodium burns in oxygen oxides are formed.

Some oxides are acidic and some are basic in nature.

(*i*) **Acidic Oxides.** These are oxides which are soluble in water, turn blue litmus red and react with bases to form salts and water. Generally, non-metals form acidic oxides.

$CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid)

CO_2 +	$2NaOH \rightarrow$	Na_2CO_3 +	H_2O
(Acidic oxide)	(Base)	(Salt)	(Water)

SO_2 +	$2NaOH \rightarrow$	Na_2SO_3 +	H_2O
(Acidic oxide)	(Base)	(Salt)	(Water)

(*ii*) **Basic Oxides.** These oxides, if soluble in water, turn red litmus blue and react with acids to form salt and water. Generally, metals form basic oxides.

CaO +	$H_2O \rightarrow$	$Ca(OH)_2$
(Basic oxide)	(Water)	(Base)

CaO +	$2HCl \rightarrow$	$CaCl_2$ +	H_2O
Basic oxide)	(Acid)	(Salt)	(Water)

MgO +	$H_2O \rightarrow$	$Mg(OH)_2$
(Basic oxide)	(Water)	(Base)

MgO +	$H_2SO_4 \rightarrow$	$MgSO_4$ +	H_2O
(Basic oxide)	(Acid)	(Salt)	(Water)

(*iii*) **Amphoteric Oxides.** The oxides which react both with acids as well as bases to form salt and water are called amphoteric oxides for example Alumininm oxide (Al_2O_3), Zinc oxide (ZnO) etc.

12.2. Acids

Chemical reactions often involve one or more acids. Acids are chemical compounds that have common characteristics.

Acids have some common properties. They

(*i*) have a sour taste

(*ii*) turn blue litmus red

(*iii*) corrode metals

(*iv*) contain only non-metals.

An acid is a compound which when dissolved in water has hydrogen available, which can be replaced by a metal to form a salt.

Experiment. Obtain some butter-milk, vinegar, lemon juice and soda water. Taste a small amount of each liquid. Test each liquid with a piece

of blue litmus paper. It is red when it is in contact with an acid and blue when in contact with a base.

Buttermilk, vinegar and lemon juice each contains an organic acid. Buttermilk contains lactic acid, vinegar contains acetic acid and lemon juice contains citric acid. Each of these organic acids is composed of carbon, hydrogen and oxygen.

Soda-water contains carbonic acid (H_2CO_3). What three elements are present in this compound ? Carbonic acid is produced by dissolving carbon dioxide gas in water under high pressure.

$$\underset{\text{(Carbon dioxide)}}{CO_2} + \underset{\text{(Water)}}{H_2O} \rightarrow \underset{\text{(Carbonic acid)}}{H_2CO_3}$$

Open a bottle of water soda and you will see bubbles pop which are escaping gas. The bubbles are carbon-dioxide gas which escape when the pressure is reduced by removing the bottle cap.

$$\underset{\text{(Carbonic acid)}}{H_2CO_3} \rightarrow \underset{\text{(Carbon dioxide)}}{CO_2} + \underset{\text{(Water)}}{H_2O}$$

How is this reaction different from the chemical change shown in the previous equation.

Table 1. (Some Common Acids)

Acid	Formula
Carbonic Acid	H_2CO_3
Hydrochloric acid	HCl
Nitric acid	HNO_3
Sulphuric acid	H_2SO_4
Acetic acid	$HC_2H_3O_2$
Hydrofluoric acid	HF

Every acid contains hydrogen. It is conventional for chemists to write the hydrogen first in the formula for an acid. When acids react with many metals, hydrogen gas is formed *e.g.*, when dilute sulphuric acid is added to zinc metal hydrogen gas is released.

Thus the definition of an acid radical is :

An acid is a compound whose molecules contain atom or atoms of Hydrogen. An atom or a group of atoms which acts as a unit is called an acid radical.

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Sulphuric Acid)}}{H_2SO_4} \rightarrow \underset{\text{(Zinc sulphate)}}{ZnSO_4} + \underset{\text{(Hydrogen)}}{H_2\uparrow}$$

$$\underset{\text{(Iron)}}{Fe} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Iron chloride)}}{FeCl_2} + \underset{\text{(Hydrogen)}}{H_2\uparrow}$$

$$\underset{\text{(Magnesium)}}{Mg} + \underset{\text{(Acetic acid)}}{2CH_3COOH} \rightarrow \underset{\text{(Magnesium Acetate)}}{Mg(CH_3COO)_2} + \underset{\text{(Hydrogen)}}{H_2}$$

A. Hydrochloric Acid (HCl)

We know when acids react with many metals, hydrogen gas is formed

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Hydrochloric acid)}}{2HCl} \rightarrow \underset{\text{(Zinc chloride)}}{ZnCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

Take a few ml. of hydrochloric acid in a test tube. Take another tube which contains water only. Put one drop of acid into this test tube with the help of a dropper. Just taste this water, then test with blue and red litmus.

You will observe that Hydrochloric acid solution is a colourless

liquid which has a pungent smell and some taste. It changes the colour of blue litmus to red but it does not change the colour of red litmus. Calcium oxide dissolves in hydrochloric acid.

$$CaO + 2HCl \rightarrow CaCl_2 + H_2O$$

(Calcium oxide)	(Hydrochloric acid)	(Calcium Chloride)	Water

Calcium carbonate forms carbon dioxide gas with hydrochloric acid.

$$CaCO_3 + 2HCl \quad CaCl_2 + H_2O$$

(Calcium Carbonate)	(Hydrochloric acid)	(Calcium chloride)	(Water)

Calcium carbonate forms carbon dioxide gas with hydrochloric acid

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

(Calcium Carbonate)	Hydrochloric acid)	(Calcium Chloride)	(Water)	(Carbon dioxide)

B. Sulphuric acid (H_2SO_4)

Take a hard glass test tube half full of water. Pour a few drops of concentrated sulphuric acid and gently shake the test tube. Is there any change in temperature? It dissolves readily in water with the evolution of heat.

You must take the precaution that concentrated sulphuric acid is always diluted with water by pouring a thin stream of the acid in well stirred water. Watér is never to be poured on the acid kept in a vessel. During dissolution, great heat is liberated and since water is liquid like sulphuric acid the hot water remains above the acid. It may even boil and splash the acid causing injury.

Now put a drop of this acid solution on the red and blue litmus paper.

We will notice that it changes the colour of the blue litmus to red.

Like hydrochloric acid it reacts with zinc and forms hydrogen gas.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

(Zinc)	(Sulphuric acid)	(Zinc sulphate)	(Hydrogen)

With carbonates and washing soda it evolves carbon dioxide gas.

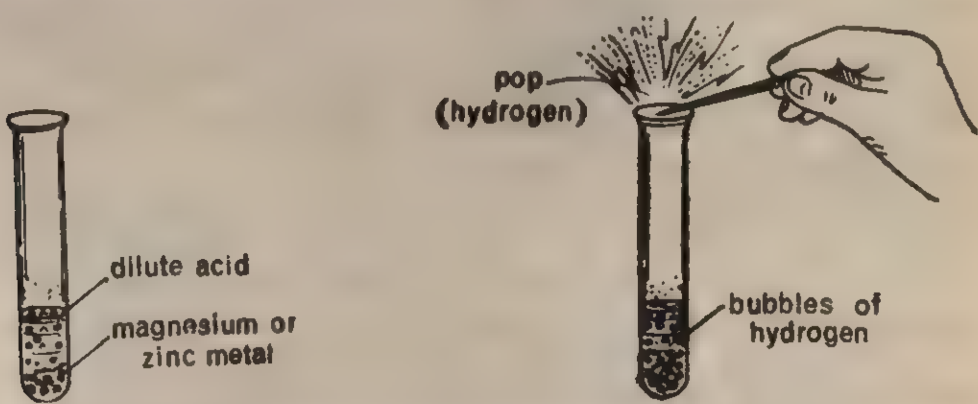


Fig. 12.1. (Left) Reaction of an acid on a metal (magnesium or zinc)
(Right) Testing the gas from an acid and a metal

In a pure state it is a colourless and a heavy liquid. It is nearly twice as heavy as water. Commercial samples have a slight brown colour due to impurities. It must be used cautiously as it is highly corrosive. Any person who gets acid on his body or clothing should flush the acid away immediately with a lot of water. If available, baking soda or milk of magnesia should be applied at once to the affected part. Baking soda and milk of magnesia neutralize acids and destroy their harmful properties.

(C) Nitric acid

Take a few ml. of nitric acid in a test tube. Observe its colour and smell it from a distance.

You will find that in a pure state it is colourless. But you will notice nitric acid bottles are brown coloured. This is due to the presence of nitrogen dioxide, which is brown. Nitrogen dioxide is formed by the decomposition of nitric acid.

Pour a few ml. of nitric acid in a test tube half filled with water. Now taste their solution and put one drop of dilute nitric acid on red and blue litmus paper. It dissolves readily in water and does not liberate heat when it is diluted with water. It has some taste and turns blue litmus red. It has no effect on red litmus.

When touched by hand, it produces yellow stain on the skin. It also reacts with metals with the liberation of hydrogen gas and with carbonates to evolve carbon-dioxide gas.

Precautions for the use of Acids :

1. Acids are corrosive to skin, clothes etc. They should be used carefully.

2. **Do not place the stoppers of acid bottles on the surface of table. Place them upside down.**

3. Keep the mouth of the test tube away from yourself and your neighbour while heating a solution of an acid in a test tube.

4. To dilute an acid, it must be poured slowly into water. Never pour water into conc. acid.

12.3. Bases

Several kinds of bases are found in common household products. Ammonia, sodium and milk of magnesia are a few examples of bases. A base is also known as antacid or alkali. Milk of magnesia is the common name for magnesium hydroxide, an effective laxative and its formula is $Mg(OH_2)$.

The ammonia commonly used in the home is a solution of ammonia gas (NH_3) in water. This ammonia solution has a chemical formula NH_4OH. The chemical name for caustic soda is sodium hydroxide ($NaOH$).

Many bases contain oxygen and hydrogen. The symbol for these two elements are grouped in the formula for a base as OH. Some bases contain more than one group.

A base is a compound which reacts with an acid to give a salt and water and no other product.

Table 2. **Some Common Bases**

Base	**Formula**
Magnesium Hydroxide	$Mg(OH)_2$
Ammonium Hydroxide	NH_4OH
Potassium Hydroxide	KOH
Calcium Hydroxide	$Ca(OH)_2$
Lead Hydroxide	$Pb(OH)_2$
Sodium Hydroxide	$NaOH$

Experiment. Rub some household ammonia between your fingers. Now rub some milk of magnesia between your fingers. Now put a piece of red litmus paper in each liquid. Record any change in colour that you observe. Red litmus is used as a test for a base because bases cause litmus to turn from red to blue. In separate containers of water, dissolve some soap and some lime (CaO). Test each of these solutions with red litmus paper. Identify the solution.

Bases have some common properties—

(*i*) Have a bitter taste.

(*ii*) Feel slippery when rubbed between the fingers,

(*iii*) Dissolve fats and oils.

(*iv*) Turn red litmus blue.

(*v*) Destroy the properties of acid.

(*vi*) Contain hydrogen, oxygen, and atleast one metal.

Those bases are compounds whose molculsee consist of atoms of metal connected with one or more hydroxyl (OH) groups.

A. Caustic Soda (NaOH)

Place a piece of sodium hydroxide on a watch glass (Do not touch with hands. Use a pair of tongs or forceps.) and leave it aside for sometime. You will notice that it absorbs moisture from air.

Now take some sodium hydroxide crystals in the test tube and add some water. Touch the test tube. What do you feel ? It is readily soluble in water. The process of dissolution in water is accompanied with the evolution of large amount of heat.

Touch this solution with your hand and also taste it. You will notice that it has a soapy touch and bitter taste.

Divide this sodium hydroxide solution in two parts. In the 1st part add blue and red litmus and to the other phenolphthalein solution. You will see that it changes the colour of the red litmus blue and colourless phenolphthalein to pink.

If sodium hydroxide solution falls on the skin or the clothes, the affected part should be immediately washed with water several times.

It is also known as caustic soda used in industries like soap manufacture, petroleum refining, textile production and plastics, etc. It is a very strong base and dissolves oil and grease readily. It is often used to unclog sink drains.

B. Calcium Hydroxide $Ca(OH)_2$

Place a piece of calcium hydroxide on a watch glass and leave it aside for some time. You will find it hydroscopic.

Now take some calcium hydroxide in a test tube and add water. Stir it with a glass rod. Does it dissolve in water? It is sparingly soluble in water. An aqueous solution of calcium hydroxide is called lime water. Pass carbon dioxide gas through lime water. It turns milky.

$$\underset{\text{(Calcium hydroxide)}}{Ca(OH)_2} + \underset{\text{(Carbon-dioxide)}}{CO_2} \rightarrow \underset{\text{(Calcium Carbonate)}}{CaCO_3} + \underset{\text{(Water)}}{H_2O}$$

Take the supernatent liquid in two test tubes. Test one with litmus paper and in other pour few drops of phenolphthalein and note down the changes.

By hydration of quick lime (CaO) a pasty white substance, slaked limes $Ca(OH)_2$ is obtained. This lime is used as disinfectant in drains, etc. Slaked lime is used for preparing mortar used in the construction of buildings and its aqueous solution is used for white washing.

12.4. Neutralization

Acid and bases react in a chemical change, called neutralization to produce water and a salt. In the process of neutralization, the properties of both the acid and the base are destroyed, resulting in a mixture of water and a salt that is said to be neutral. Neutral means that a substance is neither an acid nor a base. Thus, neither the water nor the salt affects the colour of red litmus or blue litmus.

When hydrochloric acid and sodium hydroxide are mixed, a chemical change occurs. Its products are water and salt.

$$\underset{\text{(Hydrochloric acid)}}{HCl} + \underset{\text{(Sodium hydroxide)}}{NaOH} \rightarrow \underset{\text{(Water)}}{H_2O} + \underset{\text{(Sodium chloride)}}{NaCl}$$

The presence of an acid or a base and their neutralization point may be shown with an indicator. An indicator is a substance used to show, usually by a colour change, the presence of an acid, base or other substance in a solution. Litmus paper and phenolphthalein are two common indicators. Phenolphthalein turns red in a base and is colourless in an acid.

The following examples of neutralization indicate the acid, the base and the salt in each equation.

(1) $HNO_3 + KOH \rightarrow \underset{\text{(Potassium nitrate)}}{KNO_3} + H_2O$

(2) $H_2SO_4 + 2NaOH \rightarrow \underset{\text{(Sodium sulphate)}}{Na_2SO_4} + 2H_2O$

(3) $HCl + KOH \rightarrow \underset{\text{(Potassium chloride)}}{KCl} + H_2O$

12.5. Salts

A substance formed by the neutralization reaction of an acid with a base is called salt.

Sodium chloride (NaCl) is only one of the class of compounds called salts. There are a great number of salts. There compounds have many different properties. However, all the salts are alike in that a salt contains at least one metal and one non-metal.

Thus a salt can be defined as a compound which can be formed by replacing the hydrogen of an acid

with a metal. A few examples are given below :

Reactants	Name of salt formed
1. Zn and HCl	$ZnCl_2$ (Zinc Chloride)
2. NaOH and HNO_3	$NaNO_3$ (Sodium Nitrate)
3. $Ca(OH)_2$ and CO_2	$CaCO_3$ (Calcium Carbonate)

Metallic zinc reacts with dilute hydrochloric acid.

$$\underset{\text{(Zinc)}}{Zn} + \underset{\text{(Hydrogen chloride)}}{2HCl} \rightarrow \underset{\text{(Zinc chloride)}}{ZnCl_2} + \underset{\text{(Hydrogen)}}{H_2}$$

Common salt is an essential constituent of diet. It is also used as a preservative. It is mixed with ice to get the freezing mixture. It is also used in the manufacture of chlorine, hydrochloric acid, washing soda, soap, etc.

Sodium carbonate is used in laundry, sodium bicarbonate in baking powder and also in fire extinguishers. Copper sulphate is used as a fungicide, in dyeing, calico-printing, medicines, etc.

12.6. Soaps and Detergents

The making of soap is an excellent example of a chemical reaction in which the product is a very useful substance. Soap is the product of a chemical reaction between sodium hydroxide (NaOH) and fat.

Fat + sodium hydroxide → glycerine + soap

The soap manufacturing is a long chain of bonded atoms. The properties of soap depend on whether plant or animal fat is used and whether sodium hydroxide or potassium hydroxide is used. Sodium soaps are hard soaps, and potassium soaps are soft or liquid soaps. When you wash a greasy frying pan with soapy water the soap "cuts" the grease. By rinsing the pan you wash away the grease and soapy water.

A detergent is a cleaning substance. Synthetic detergents are man-made chemical compounds that have a cleansing action similar to soap. Their great advantage is that they work as well as in hard water as they do in soft water.

Soaps and detergents are of one common use. We use them for cleaning our bodies, clothes and utensils, etc. Soaps and detergents are also being used in laundry, textile industry, shaving soaps, shampoos, water proofing cement, etc.

Efflorescence and Deliquescence

In some cases, hydrated salts lose their water of crystallization in the atmosphere at normal temperature ; this is called efflorescence.

e.g.—Na_2CO_3. 10 H_2O.

Some substances absorb water from the atmosphere and form saturated solutions. This is called deliquescence

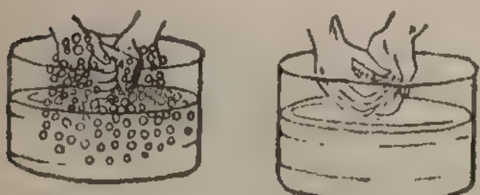
e.g.—$Zn\ (NO_3)_2$. NaOH.

12.7. Hard and Soft Water

Of everyday importance is the use of soap for personal cleanliness and

for the washing of dishes and clothes. Sometimes though, the soap is not as effective as it could be and instead of getting a lather easily unpleasant scum is formed. If there is difficulty in forming a lather then the water is said to be hard.

Hard water does not readily form a lather with soap whereas soft water forms lather with soap readily.



(a) Soft water — *Easily lathers with soap*

(b) Hard water — *Does not lather with soap*

Fig. 12.2.

Well and river water has less ability to produce lather while tap water forming more lather is called soft water.

Hard water is responsible for the formation of the ring you may have observed around the inside of a washbowl or bath tub. It also leaves a scaly, mineral deposit in water boilers and in kitchen utensils used to heat hard water.

Hard water contains dissolved calcium (Ca), Magnesium (Mg) or iron (Fe). Soft water is nearly free from dissolved minerals. Soft rain water absorbs CO_2 from the air as it falls from clouds to earth. CO_2 dissolved in the rain water forms a weak acid solution. The addition of CO_2 to water produces carbonic acid (H_2CO_3).

$$CO_2 + H_2O \rightarrow H_2CO_3 \text{ (carbonic acid)}$$

When carbonic acid, a weak acid is placed in contact with limestone rock, it dissolves the lime stone. Lime stone rock is composed of calcium carbonate ($CaCO_3$). Thus, when the lime stone dissolves in the water, calcium is added to the water, making it hard.

$$\underset{\text{(Carbonic acid)}}{H_2CO_3} + \underset{\text{(Calcium carbonate)}}{CaCO_3} \rightarrow \underset{\text{(Calcium bicarbonate)}}{Ca(HCO_3)_2}$$

Dissolved magnesium (Mg) or dissolved iron (Fe) cause water to become hard.

Hardness can be removed by *Distillation*. When water changes into steam or vapours and again it is condensed back to water, this is distillation. This distilled water does not contain any mineral salts. That is why it is not good for drinking purpose but we use it in car batteries.

Temporary hardness can be removed by using Clark's process. This involves the addition of a carefully calculated amount of calcium hydroxide so that the calcium is removed as the insoluble carbonate.

$$\underset{\text{(Calcium bicarbonate)}}{Ca(HCO_3)_2} + \underset{\text{(Calcium hydroxide)}}{Ca(OH)_2} \rightarrow \underset{\text{(Calcium carbonate)}}{2CaCO_3} + \underset{\text{(Water)}}{2H_2O}$$

For the removal of the other salts like sulphates and chlorides of calcium and magnesium we use a method called Permutit process.

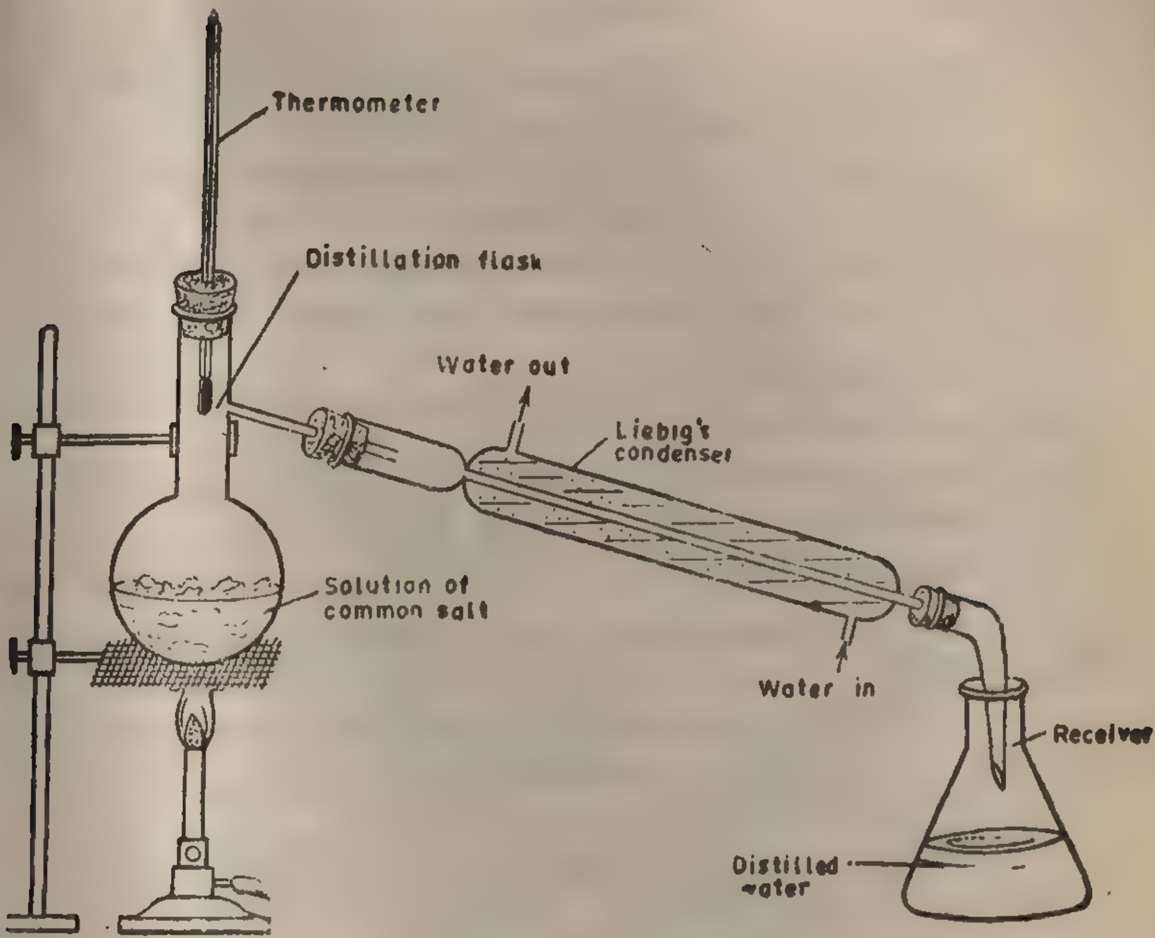


Fig. 12.3. Distillation in the laboratory

Washing soda (Na_2CO_3) is one of the compounds used to remove dissolved calcium from hard water.

$$\underset{\text{(Calcium chloride)}}{CaCl_2} + \underset{\text{(Sodium carbonate)}}{NaCO_3} \rightarrow \underset{\text{(Calcium carbonate}}{CaCO_3\downarrow} + \underset{\text{(Sodium chloride)}}{2NaCl}$$

Sodium Zeolite is very effective in softening hard water. When hard water passes over the zeolite, it absorbs the dissolved calcium in the hard water and replaces it with sodium. Hard water + sodium zeolite → Calcium zeolite + soft water.

There are some advantages of hard water also. For bone and teeth formation calcium is an essential item of diet and so the best drinking water contains calcium.

SUMMARY

1. Oxides are formed when metals and non-metals are burnt in air.

2. Some oxides are acidic and some oxides are basic.

3. The oxides of non-metals (CO_2, SO_2) are acidic in nature.

4. The oxides of metals (CaO, MgO) are basic in nature.

5. With water acidic oxides give acids but basic oxides give alkalies.

6. Acidic and Basic oxides react with alkalies and acids respectively to give salt and water.

7. The oxides which react both with acids as well as bases to form salt and water are called amphoteric oxides.

8. Acids are chemical compounds that have common characteristics :

(*i*) Same in taste, (*ii*) Turn blue litmus red,

(*iii*) Corrode metals, (*iv*) Contain only non-metals.

9. All acids contain hydrogen atoms in their molecules *e.g.*, HCl, H_2SO_4, HNO_3 etc.

10. Bases are oxides and hydroxides of metal. Bases which dissolve in water form alkalies. They have common characteristics :

(*i*) Have a bitter taste,

(*ii*) Found slippery when ribbed between the fingers,

(*iii*) Dissolve fats and oils,

(*iv*) Turn red litmus blue.

11. When alkalies react with acids, salt and water are formed. This reaction is known as neutralization.

12. A substance formed by the neutralization reaction of an acid with a base is called salt.

13. Common salt is an essential constituent of our diet.

14. Efflorescent substance lose water of crystallization on exposure to the atmosphere whereas deliquescent substances absorb water from saturated solutions.

15. Soaps are prepared by the reaction of oils with NaOH. Glycerine is obtained as a by-product.

16. Detergents are used for their better cleansing properties than soaps.

17. Water is of much use in our daily life.

18. Some water is hard and some is soft.

19. Hardness is due to the presence of $CaCl_2$, $MgCl_2$, $CaSO_4$, $MgSO_4$, $Ca(HCO_3)_2$. $Mg(HCO_3)_2$, etc.

20. It can be removed by boiling water, by adding lime or by the permutit method.

21. Hard water has got some advantages also. For bone and teeth formation calcium is an essential item of diet.

QUESTIONS

1. List the characteristics of acids.
2. Name three examples of acids.
3. What are the formation for carbonic, nitric, sulphuric and hydrochloric acid ?
4. Name three bases.
5. What are the general characteristics of bases ?
6. What are the reactants and products in neutralization ?
7. How are the properties of acids and bases changed in neutralization ?
8. What is chemical indicator ? Name two chemical indicators.
9. What problems are caused by hard water ?
10. What three mineral elements make water hard ?
11. (*a*) What are acidic oxides ? Give two examples.
    (*b*) What are basic oxides ? Give two examples.
    (*c*) What are amphoteric oxides ? Give two examples.
12. If you are given three test tubes containing an acid, a base and water respectively, how will you determine the content of each one of them ?
13. Explain with equations :
    (*a*) Efflorescence, (*b*) Deliquescence.
14. Explain with the help of equations how the following bases are formed :
    (*a*) Aluminium Hydroxide, (*b*) Potassium Hydroxide,
    (*c*) Calcium Hydroxide, (*d*) Sodium Hydroxide.
15. Explain with the help of equations how the following salts are formed :
    (*a*) Copper sulphate, (*b*) Sodium chloride,
    (*c*) Calcium nitrate, (*d*) Calcium carbonate.

16. Why is distilled water used in research laboratories ?

17. Write the equations for the reactions by which the following oxides can be obtained :

(*i*) Sulphur dioxide
(*ii*) Magnesium oxide
(*iii*) Calcium oxide
(*iv*) Carbon dioxide.

17. What indicators do you use to test for the following ?

(*i*) An acid (*ii*) A base.

13

PRESERVATION OF SELF—I

13.1. Introduction :

Food is needed by the body for energy and for growth and repair of body tissues. You must eat to obtain energy for breathing, thinking, walking, talking and all other body activities. The food you eat adds numerous materials to your body tissue causing you to increase in size. In addition, food provides the raw materials for the synthesis of body fluids and replacement of worn out cells.

Nutrition is the science dealing with the study of foods and how the body uses them. A food is a substance which provides nourishment and energy for the body. Food combines with oxygen to yield energy and waste products.

How do plants get their food ? Green plants have the ability to make their own food. They can make food from simple things like carbon-dioxide of the air, sunlight and water. The green colour helps the plant to make its own food. Their green colour is due to the presence of a chemical substance called *Chlorophyll*.

Photosynthesis is the process of food manufacture in a green leaf.

Fig. 13.1. Leaf as a factory

This word is made up of two words—*Photo* meaning light, and *synthesis* meaning combining.

In photosynthesis energy of the sun is utilised to make sugar in the leaf. It happens in the presence of carbon-dioxide obtained from the air, and water obtained from the soil. Oxygen is given out to the air as an extra product. The sugar formed is changed into starch.

Sunlight is Necessary for Starch Formation :

Experiment. Take a potted plant, which has been very well watered. Place it in the dark for a period of 24 to 48 hours.

Pluck one of its leaves. Test it for starch. If it shows presence of starch, keep the plant in dark. If there is no starch present in the leaf, go ahead with the experiment.

What does this part of the experiment show ? The plant is now free of starch.

Wrap carefully one leaf of the starch-free plant with a black paper on which a design is cut. (Light can only pass through the cut part of the paper.) Fix this paper firmly on the leaf by means of clips or thread.

Keep the potted plant in sunlight for a few hours. Then remove the covered leaf from the plant and test it for the presence to starch.

It will be observed that starch is present in the leaf only in the portion which was under the design cut on the paper. Why ?

What do we infer from this experiment ?

Starch is formed in the part of the leaf exposed to sunlight, and not in the part of the leaf, which is not exposed to sunlight.

Chlorophyll is Necessary for Starch Formation.

Experiment. Select a plant the leaves of which have green and yellow patches. Tapioca, crotons and coleus are examples of such plants.

Keep this plant in the dark for 24 to 48 hours to remove starch from it.

Fig. 13.2. Light is necessary for the preparation of starch

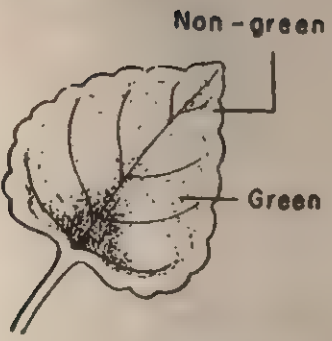


Fig. 13.3. Coleus Leaf

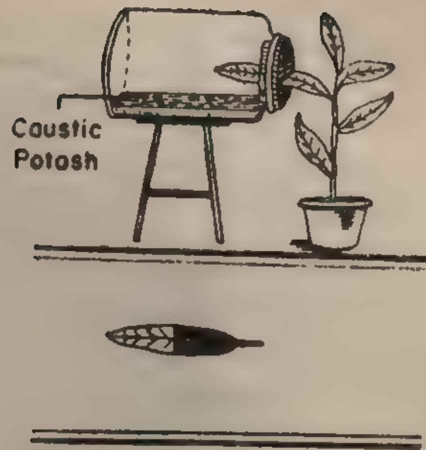


Fig. 13.4. Carbon dioxide is necessary for starch formation.

Expose it to sunlight for a few hours. Test one leaf for the presence of starch as before.

It will be observed that only the green part of the leaf has taken blue-black colour. The non-green part of the leaf remains uncoloured.

What do you infer from this experiment ?

Carbon Dioxide is Necessary for Starch Formation.

Experiment. Keep a plant in a dark room for 24 to 48 hours to remove starch from it. When the plant is still in darkness, fix one of its leaves through a split-cork in a bottle containing caustic soda or caustic potash. Caustic soda or caustic potash will absorb carbon dioxide. You should be careful not to touch the caustic.

Bring the apparatus to sunlight and keep it there for a few hours. Test this leaf for the presence of starch.

It will be observed that the part of the leaf, which was inside the bottle, does not become blue-black. The part of the leaf, which was outside becomes blue-black. Why ?

Your teacher will demonstrate another experiment for the same purpose.

Fig. 13.5 shows the setting of the apparatus for this experiment, which is set early morning after keeping the plant in darkness for 24 to 48 hours.

The side tube X is attached to an aspirator. It sucks air through the bell jar. The potash bulb absorbs carbon dioxide from the air entering the bell jar. Caustic potash in the dish under the bell jar absorbs carbon dioxide within the bell jar.

The apparatus is kept in sunlight for a few hours. One leaf from this plant is then tested for the presence of starch.

What do you think will happen ? Why ?

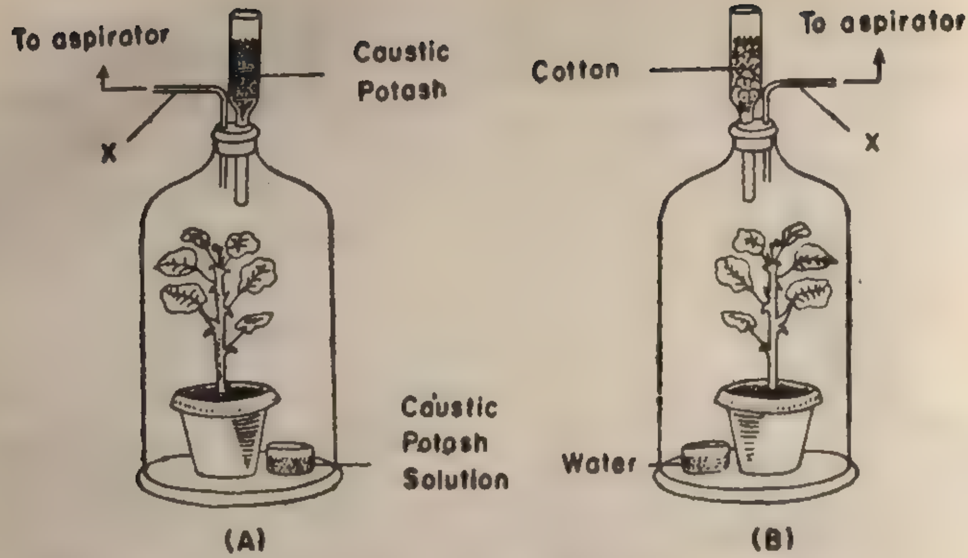


Fig 13.5. Carbon dioxide is necessary for starch formation.

Oxygen is produced during Starch Formation :

Experiment. Take water in a large beaker. Dissolve in it some soda bicarbonate. Why ? Soda bicarbonate will add carbon dioxide to the water.

Fig. 13.6. Oxygen is produced during starch formation.

Place some water plants in this water. Invert a short-stemmed funnel over these plants. Invert a test-tube full of water over the stem of the funnel.

Place the apparatus in sunlight. Observe what happens.

After some time bubbles of a gas seem to arise. The gas is collected in the tube placed over the stem of the funnel.

Take off the test-tube keeping it inverted. Test the gas in the test-tube by taking a glowing splinter into the test-tube.

It will be observed that the splinter bursts into a flame to prove that the gas in the test-tube is oxygen.

Let us review what we have studied about the structure and the working of a leaf so far. Light passes through the transparent epidermis and reaches the inner cells.

The veins distribute water to every cell of the leaf.

Carbon dioxide needed to make starch gets in through the stomata. Oxygen produced within the leaf also gets out through stomata.

The leaves produce food. This food is used by the plants for its growth. Extra food is stored in various parts of the plant.

The food is also used to provide energy to the cells. For the production of energy, the food is broken down into simple substances of which it is made. These substances are carbon dioxide and water. The process of liberating energy from food is called respiration.

Some plants have a special method of capturing food. Their leaves are specially modified to capture insects and other small animals. These are called insectivorous plants. Leaves of this insectivorous plants called pitcher plant are folded in the form of a pitcher with a lid. As the insect alights on the leaf, it gets trapped. Another example of insectivorous plant is bladderwort.

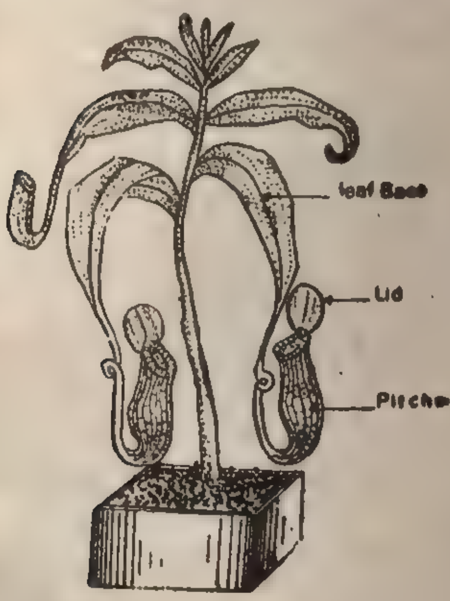


Fig. 13.7. Pitcher plant

13.2. Nutrition in Animals :

Nutrition means the series of processes in the feeding of organism, the obtaining and taking in of food, the processes to which it is subjected and its final utilization by the organism for various purposes.

Plants take in simple inorganic substances, such as carbon-dioxide from air and water and minerals from the soil, and convert them into complex organic substances which may be oxidised to release energy or synthesized into protoplasm. This nutrition is *autotrophic*.

Animals do not have chlorophyll. They cannot make their own food and take in complex substances either from a plant source or from an animal source. They then convert these food substances into simple substances which are either oxidised to release energy or are utilized to form the body structure. This nutrition is *holozoic*.

Some organisms, *e.g.*, Mucor, Rhizopus and certain bacteria, cannot make their own food, but obtain it from dead organic matter either directly absorbing these substances or first digesting them outside their body and then absorbing them. Such nutrition is termed saprophytic and the organisms which feed in this way are called *saprovores*.

Still some other organisms obtain their food from other living individuals. Some examples are : ringworm (a fungus) grows on the skin of the host by digesting food from there, fleas suck the blood of the animal they live on, tapeworms absorb digested food from the alimentary canal of the animals they live in. This mode of nutrition is *parasitic*. The organism thus feeding is a parasite and the organism on which the parasite feeds is a host.

We all eat food. Do you know why we eat our food ? What will happen if one does not take food for sometime ? Naturally he feels hungry. What will happen if he still does not take food ? He feels weak and is not normally active. In fact he does not have sufficient energy to work.

People want to reduce fat from their body. What is the simple way of doing this ? They reduce the quantity of their food or start fasting. This reduces the fat from their body. What has actually occured ? The cells in the body do not grow at all or they grow improperly in the absence of food. When there is no growth new cells are not formed.

Can you now say what does the food do for our body ? Of course, food provides us energy. It helps our body to grow and to build new tissues.

13.3. What happens to food inside the body ?

We all take in food. The intake of food inside the body is called *ingestion*. The food, which is taken in, is changed into simpler substances. This is called *digestion*. The change occurs in the alimentary canal. This digested food is then absorbed. The process is called *absorption*. The undigested part is thrown out of the body. This process is called *egestion*. To help in this complicated process, most animals have special system of organs, called *digestive system*. Let us study the various parts of the alimentary canal and see what happens to the food when it passes through these various parts. First part of the

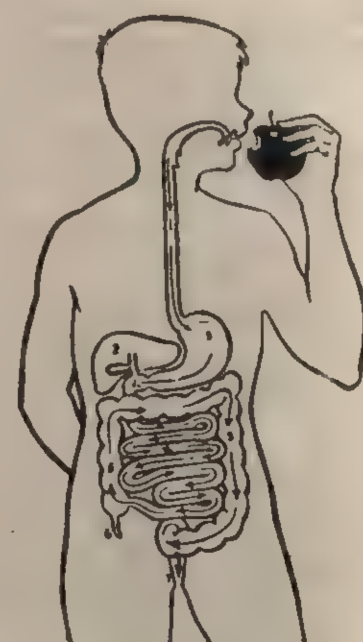


Fig. 13.8. Alimentary Canal

1. Oesophagus. *2. Liver.*
3. Stomach. *4. Small Intestine.*
5. Large Intestine. *6. Appendix*
7. Rectum.

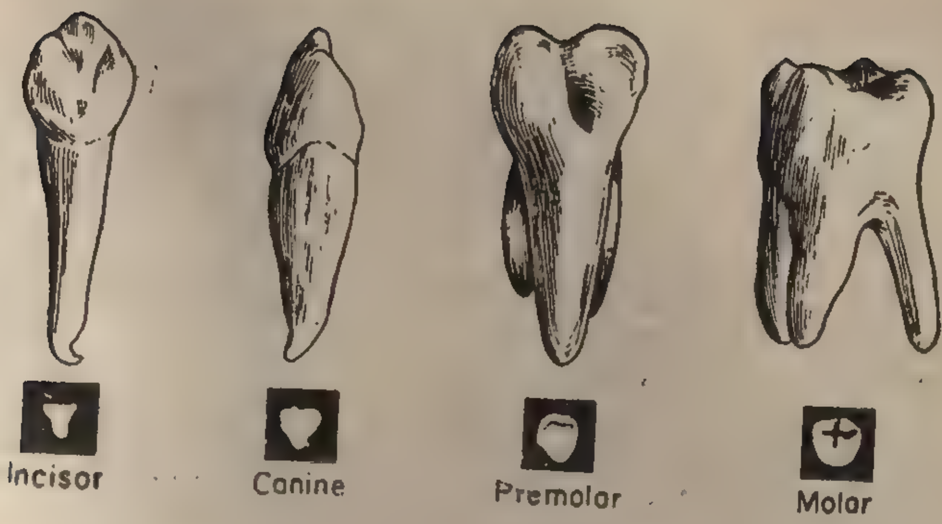


Fig. 13.9. The different kinds of teeth

alimentary canal is the mouth. The mouth has teeth, tongue and salivary glands. All human beings have two sets of teeth, the milk teeth and permanent teeth. Teeth are of different shapes and sizes.

They are classified as Incisors, Canines, Premolars and Molars. All teeth are made up of a solid tissue called dentine. A part of the tooth is in the socket of a jaw. It is the root. The part projecting out of the socket is the crown. It is covered by a strong layer, the enamel.

The tongue consists of several sets of striated muscles by which it moves in various directions.

Three pairs of salivary glands are present in the mouth. They secrete saliva, which converts starch into sugar.

Next part of the alimentary canal is the Oesophagus., It is a long tube, No digestion takes place in this part.

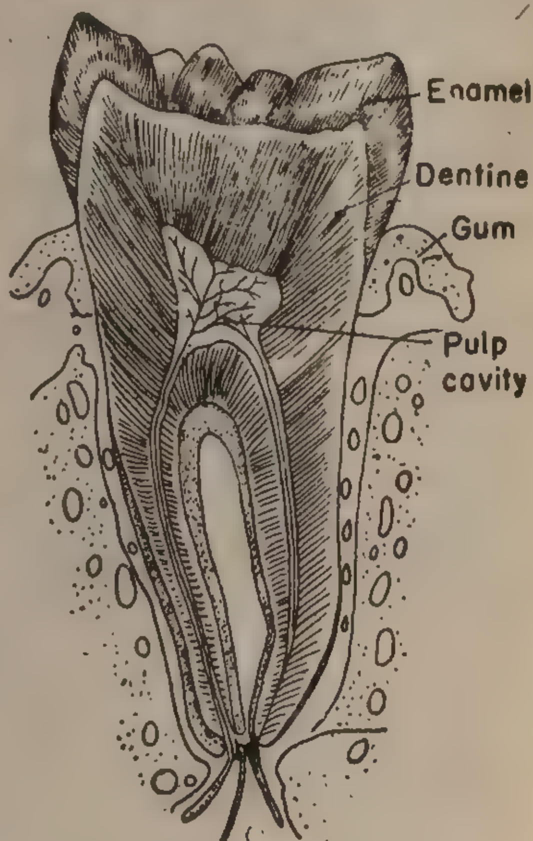


Fig. 13.10. Structure of a typical Human Tooth

Oesophagus leads into stomach which is in the form of an ovoid sac. Gastric juice contains different enzymes which act on different kinds of food and convert them into simpler forms.

Next, the food passes into small intestine where more enzymes act on the food. The large intestine is the next part of the alimentary canal where no digestion takes place. Only water is absorbed here. The undigested food matter is passed out from the rectum through the anus.

Fig. 13.11. (a) The two jaws

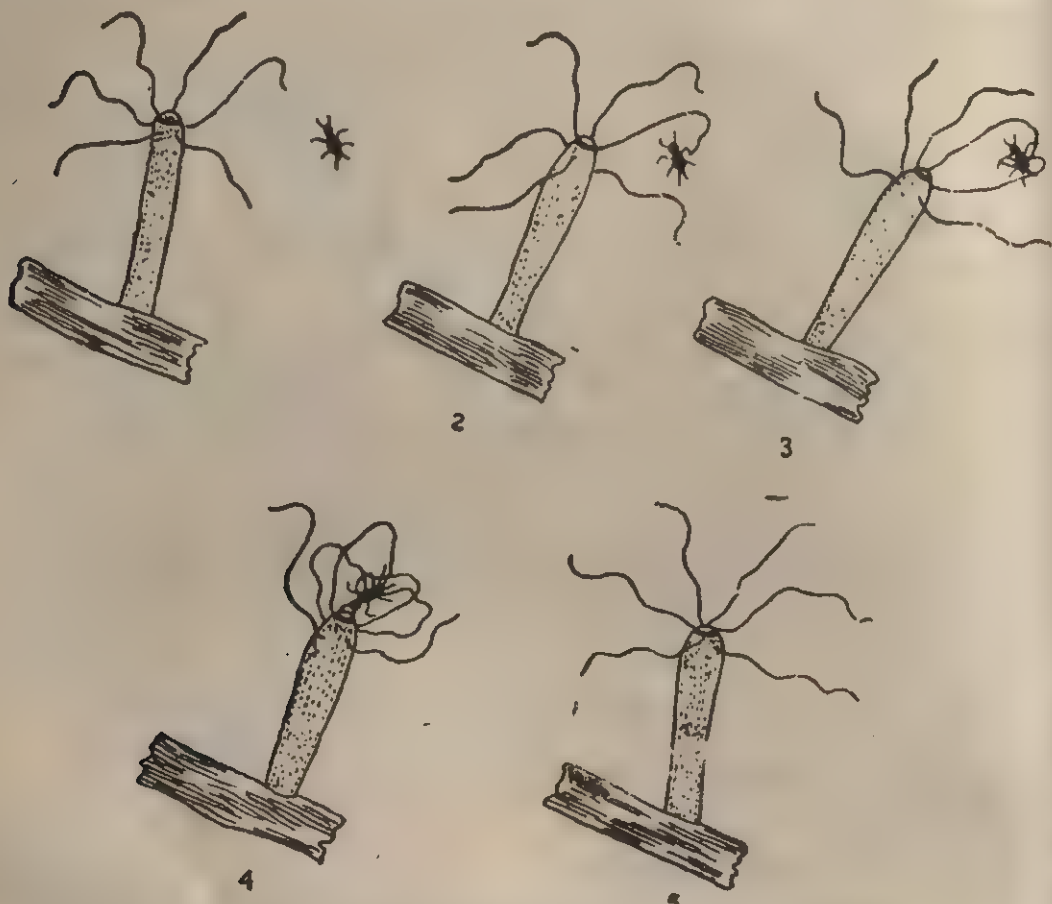


Fig. 13.11. (b) Food Catching in Hydra

The process of ingestion, digestion absorption and egestion is achieved by different animals in different ways.

Amoeba engulfs the food by throwing pseudopodia around it along with some water. The beating cilia of paramoecium force food particles into the protoplasm together with water. The food is then digested in the cytoplasm of the organism.

Hydra, a coelentrate, puts the food in its mouth with the help of tentacles. The food then enters the body cavity and is digested there by the digestive juices.

Earthworm an Annelid, burrows in the soil, there it swallows the mud through its mouth. As this mud passes through its alimentary canal the organic matter in it is extracted by the animal.

Vertebrates also exhibit different modes of ingesting food. In all vertebrates food is taken into the mouth. It is then pushed into the alimentary canal, where it is digested and absorbed by the blood to be carried to all parts of the body.

In mammals nutrition begins with the lips and teeth, which together seize the food and pass it into the alimentary canal where it is digested.

13.4. Respiration

Energy is needed by living as well as non-living things to do work. Without energy they stop doing work. Our body needs energy to carry on all its activities. Even when we are not working apparently, some organs of our body, such as the heart, brain, kidney and lungs are working. Hence, all the twenty-four hours energy is needed by the body.

Where from do we get this energy ? You have studied in an earlier chapter that we all eat food. The foods, which we eat, contain chemical energy. During digestion the foods are broken into simpler forms in the alimentary canal. They are then absorbed by the walls of the intestine and carried by the blood to the various parts of the body. Finally the food becomes a part of the cell matter.

The energy of the food is of no use because it cannot be used till it is released from the food. When oxygen combines with these food materials in the cells, oxidation of these food materials take place, liberating energy and carbon dioxide.

How does oxygen reach the cells ? The oxygen necessary for oxidation is taken in by the help of the certain organs, called respiratory organs, and the carbon dioxide formed during oxidation of food is given out by them.

Respiratory System

Fig. 13.12 shows the respiratory organs of a human being. The chief organs of respiration in a human body is a pair of lungs. These are enclosed

in the thoracic cavity or thorax, which has bony framework of the thoracic vertebrae, ribs and sternum. The air from outside passes through the external nostrils and nasal passage into the pharynx. Certain partitions separate the nose cavity from the mouth. A certilaginous partition divides this cavity into the right and left chambers. There are fine little hair in the nasal cavity. These hair filter the dust particles and foreign matter, thus preventing their entry into the lungs. The air in the nose cavity becomes warm and moist. The surface of the nose cavity is sticky. It holds the fine dust particles.

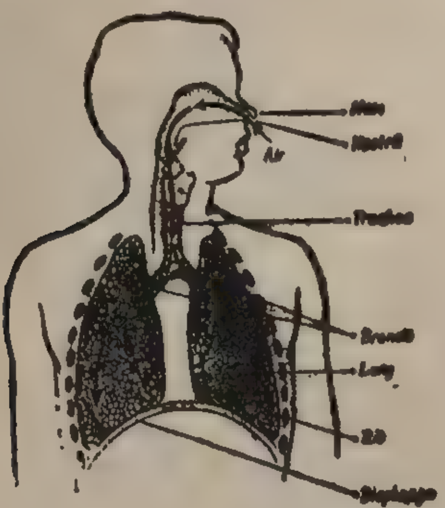


Fig. 13.12. Respiratory organs of Man

The air next enters the hinder part of the mouth cavity, pharynx. The lower part of the pharynx leads into two tubes. The front tube is the wind pipe or trachea. The tube at the back is the food pipe or oesophagus. Masses of soft tissues, known as the tonsils and adenoids, are present in the pharynx. These masses become infected. They are then enlarged and cause a lot of pain.

From the pharynx the air gets into the wind pipe or trachea. The narrow slit-like opening of the wind pipe is called the glottis. The wind pipe is a narrow tube traversing the neck. It is ventral to the gullet. The anterior part of the windpipe is enlarged to form the larynx, popularly called the Adam's Apple. The larynx is more prominent in males than in females. Inside the larynx lie the vocal cords. There are two folds of ligaments stretched across the cavity. Air forced out of the lungs causes the vocal cords to vibrate and produce sound.

The pharynx is the common passage for both food and air. From pharynx the food gets into the oesophagus and air into the trachea. The entry of food and air is automatically regulated into their respective passages, particularly while eating. The epiglottis closes the opening of larynx when food is being swallowed. Sometimes particles of food get into the windpipe, but at once there is choking and coughing which causes the food to come out of the windpipe.

The trachea is supported by cartilaginous rings. The trachea is divided into two tubes at its lower end. These form the left and the right bronchi. Each bronchus leads into the lungs of its corresponding side.

The bronchi and trachea are quite elastic. They are prevented from collapsing owing to the presence of rings of cartilage embedded in their walls. Hence, air can freely pass through these tubes.

There is a lining of mucous membrane in the entire respiratory tract. The moist lining catches the microbes or minute dust particles which happen to get into the respiratory tract. The air thus becomes free from suspended particles.

Fine hairs-like projections are present on the cells of mucous membrane of trachea and bronchi. The cilia push the dust particles caught on the sticky membrane by their constant movements. These particles are thus prevented from reaching the air passages of the lungs.

The two bronchi divide and redivide to form the network of tubes just like the branches of a tree. These fine and smaller tubes are known as bronchioles. Each bronchiole ends into a small chamber—the air sac, called an alveolus.

The wall of an alveolus consists of one layer of flat cells which on the outside is covered by a network of very fine blood capillaries. There is only one thin membrane separating the air and blood. The exchange of gases takes place by simple diffusion through the thin membranes of the capillaries and the air in the alveoli.

How many alveoli are there in a lung ? There are about 300 million alveoli in each lung. They very much increase the absorbing surface of a lung. When flattened the alveoli may cover an area of over 100 square metres. Each lung is cone-shaped. The lung is concave at its lower surface. Why do you think it is so ? The diaphragm which bulges into the body cavity is easily accommodated. The two lungs are unequal in size. The right lung is larger than the left. The right lung has three lobes, whereas left lung has two lobes. Each lung is covered by a double layered membrane, called the pleura. The space between these two layers is filled with a fluid.

Gaseous Exchange in Lungs and Tissues

The atmospheric air has about 21 per cent of oxygen and 0·03 per cent of carbon dioxide. So the air which we breathe in contains 21 per cent of oxygen and 0·03 per cent of carbon dioxide. Is the percentage of these two gases the same in the air we breathe out ? No, it is not so. The air which is breathed out contains about 16 per cent of oxygen and 4·5 per cent of carbon dioxide. What changes the percentage of these gases ? Naturally the change occurs within the body. About one-fourth of the oxygen content of the air which we breathe in is utilized. This loss of oxygen is compensated by giving out about the same volume of carbon dioxide. The carbon dioxide, which

is breathed out, is obtained from the blood which comes to the lungs. The nitrogen content of the air which we breathe in and breathe out remains nearly the same—about 79 per cent of air.

As there is a big diversity in animals according to their size, structure, place of living, etc., they respire in many different ways. According to their respiratory surface, these animals may be known as body surface breathers, skin breathers, air tube breathers, gill breathers and lung breathers.

Body Surface Breathers. Protozoans such as Amoeba and Paramoecium obtain their oxygen supply through the body surface, which is a thin layer of cell membrane. Oxygen from the water diffuse into the body of the organism and carbon dioxide produced during oxidation of food diffuses outside the body.

Hydra, a coelenterate, also respires in a similar manner to carry on its life activities.

Earthworm is an example of skin breather. The skin of earthworm is moist. It has a rich supply of blood.

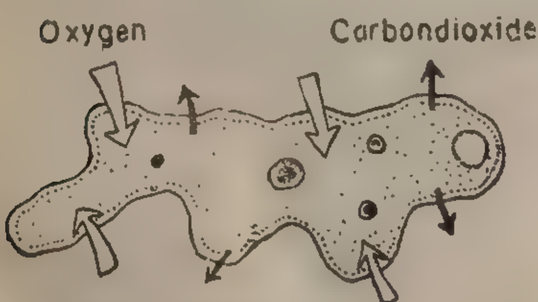


Fig. 13.13. Amoeba—a body surface breather

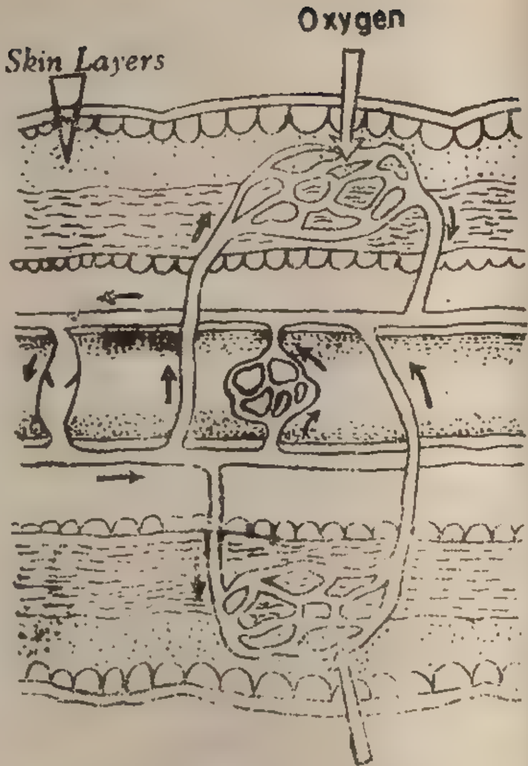


Fig. 13.14. Earthworm—a skin breather

Oxygen from air dissolves in the film of mucus and other body fluids on the skin. It diffuses into the blood plasma in solution and combine with haemoglobin. The unstable oxyhaemoglobin in blood is carried to different tissues and cells where it releases oxygen to oxidise food. Carbon dioxide produced during oxidation is collected by the blood and brought back to the skin when it is diffused out. A frog also breathes through the skin when it is completely immersed in water or is undergoing hibernation.

Air Tube Breathers

Cockroach, housefly, moth, etc., are air tube breathers.

The cockroach has a network of

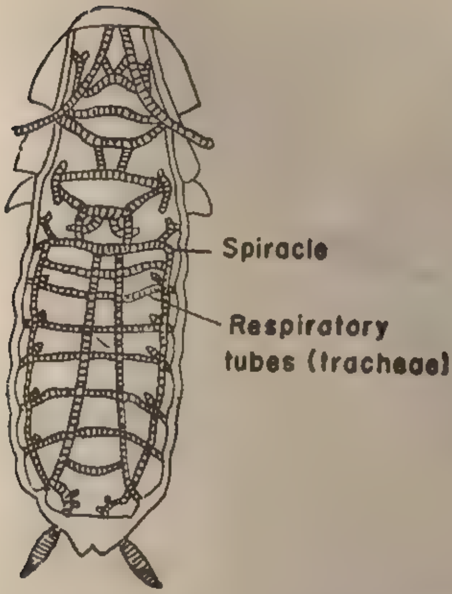


Fig. 13.15. Cockroach—an Air Tube Breather

respiration tubes in its body, known as trachea and their branches. Trachea are spread inside the body.

Gill Breathers

All gill breathers are aquatic. Fish are the most prominent gill breathers. Prawns, tadpoles of frogs and toads and young cartilaginous fishes are all examples of gill breathers. Gills are the outgrowths of the body. They contain very fine blood vessels just below the skin. Exchange of gases takes place by diffusion between the blood in the gills and the surrounding water.

13.5. How ||does exchange of gases take place in plants ?

The lower surface of the leaf has a large number of stomata. These are all openings through which exchange of gases take place in plants. For respiration, respiratory surface for the exchange of gases is essential.

13.6. Transport System within the Body.

Our body requires energy to carry on the various life activities. We get this energy from the food we eat. The food is digested in the alimentary canal. But the alimentary canal only does not require the food. It must go to all parts of the body. How does the food reach the different parts of the body, say the brain or the foot ? You may say that the digested food is absorbed into the blood in our small intestine. The blood then carries the absorbed food to the different parts of the body.

The red blood corpuscles will be

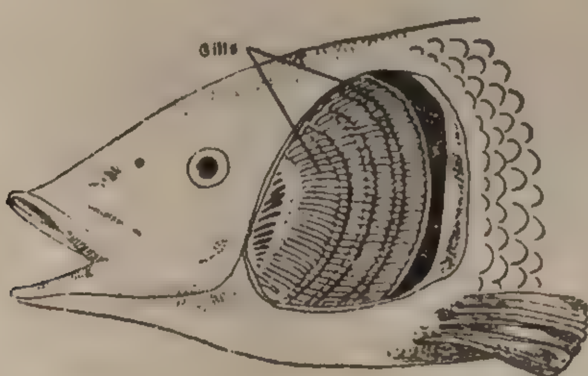


Fig. 13.16. A Bony Fish—a Gill Breather

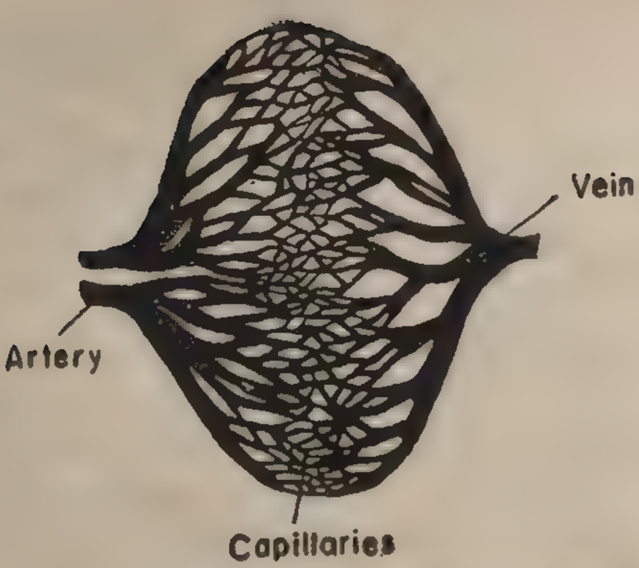


Fig. 13.17. An artery breaks into capillaries, which unite to form veins

seen moving in a stream towards one direction. It is in fact the movement of the blood in the blood vessels.

The blood goes to all parts of our body. We may say that it circulates within the entire body. Let us assume the heart to be the central pumping station for our convenience to study the circulation of blood.

The blood is forced out of the heart through the blood vessels, called arteries. The large arteries divide into smaller branches in the tissues. The arteries go on dividing and redividing till they form very fine blood vessels called capillaries (Fig. 13.17). The capillaries pass between the cells. They bring blood close to the cells to facilitate the exchange of the materials from the blood to the cells and vice-versa.

The capillaries join together and form larger blood vessels, called veins. The blood returns to the heart through the veins.

Let us think a little more about the arteries and veins. The blood passing through the arteries is coming

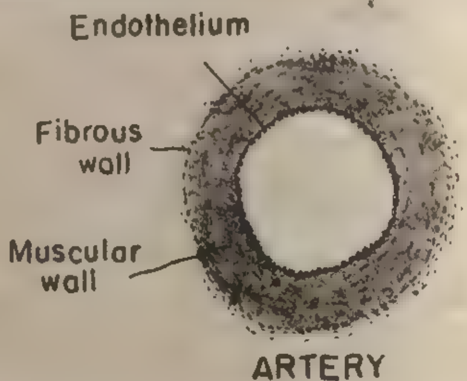


Fig. 13.18. An artery has thick muscular wall

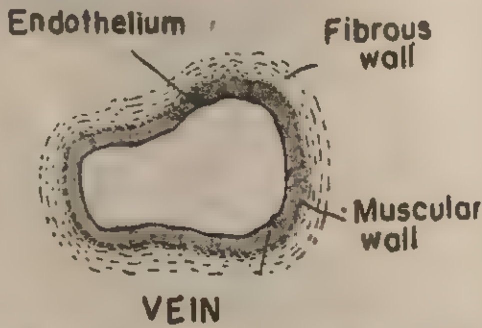


Fig. 13.19. A vein has thin muscular wall

direct from the heart. It contains plenty of oxygen and is bright red in colour. We call this as the oxygenated or arterial blood. Arteries carry this blood to the various parts of the body. An artery has thick muscular walls (Fig. 13.18).

The blood passing through the veins is collected from the tissues. It has lost its oxygen and is dark red in colour. It is known as deoxygenated or venous blood. This blood contains a lot of carbon dioxide. The blood in veins also contains other waste matter of the cells. Veins bring the blood to the heart. The walls of veins are not so muscular (Fig. 13.19). They have valves to prevent the flow of the blood away from the heart when it is going towards the heart against gravity.

HEART

We have already studied in this chapter that blood is contained in blood vessels. These blood vessels are closed and form a closed blood vascular system. Do you remember the open blood vascular system in cockroach ?

The movement of blood inside the blood vessels is called circulation. It was a mystery till 1628 when a British physician William Harvey proved that the heart is responsible for maintaining the circulation of blood inside the blood vessels by its pumping force. People before Harvey believed that the heart was a place in the body to recognise the feelings of love and courage. You might have heard many people talking so about the heart even today. Of course, poets in all languages have always been describing the heart concerned with all sorts of emotions.

Today we know that the heart is the most remarkable organ in our body. It keeps on pumping the blood by its rhythmic contraction and relaxation throughout the life of an individual.

Position and Morphology of the Heart.

Activity. Examine the chart showing the heart in the human body. Observe in what part of the body it is situated.

Fig. 13.20. External View of the Human Heart.

The heart is located more or less in the central part of thorax. It is behind the sternum between the two lungs and a little towards the left side. The heart is more or less of the size of a clinched fist of an individual.

Demonstration. Your teacher will show you the heart of a sheep. Compare it with the model of the human heart in your laboratory.

The heart (Fig. 13.20) is a muscular organ. It is enclosed in a double-walled sac called pericardium. A fluid is filled between these two layers. This fluid provides protection to the heart against shocks and friction and renders its working much easier. In the body the heart contracts and relaxes in a definite cycle. A short pause of rest follows each contraction.

There are several blood vessels on the heart.

13.7. How does transport take place in plants ?

Take two balsam plants. Place one of them in a jar of plain water and other in a jar of coloured water. Keep for some time. The plant in the coloured water will show colour. How has the colour appeared on the stem and on the leaves ?

Observe the cut end of the stem. We will see that coloured patches are present only in certain areas of the stem. This is where the conducting vessels are located. Plants have two types of conducting vessels—xylem and phloem. Xylem carries the water and minerals absorbed by the root. Phloem carries food material from the leaves. Xylem and Phloem together

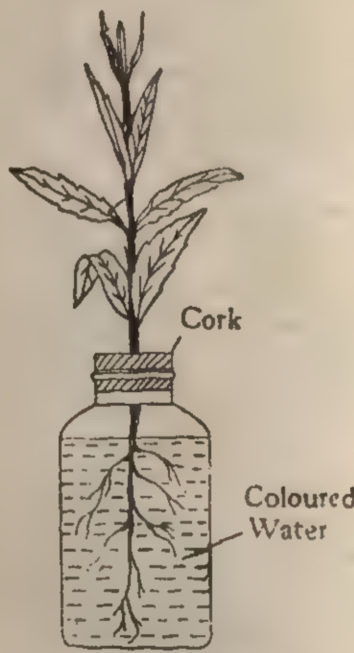


Fig. 13.21. Transport of water through the stem

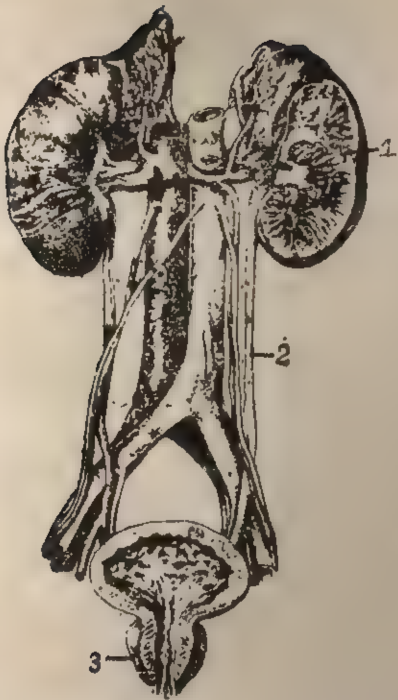
are known as vascular bundle. In a leaf these vascular bundles form a fine network and this is called venation.

13.8. How does body get rid of its wastes ?

Excretory Systems

Excretion is the removal of metabolic waste matter from the body. The removal of the undigested food material as the faeces is not excretion, because the undigested food has not undergone any metabolic activity at any stage.

The chief waste products are carbon dioxide, nitrogenous waste, such as urea and water. Urea is the



1 Kidney. 2. Ureter. 3. Bladder
Fig. 13.22. The Principal Organs to help Excretion

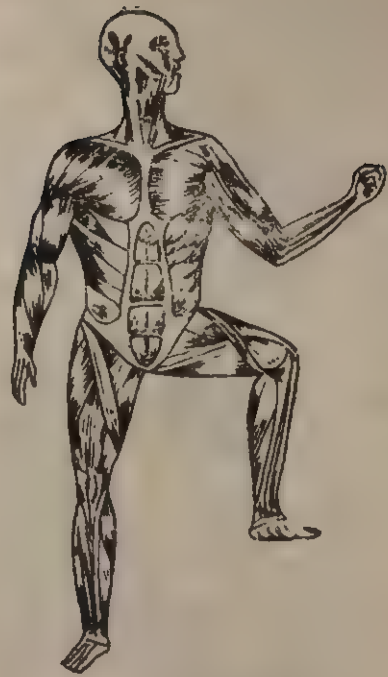


Fig. 13.23. Muscles Covering the Body.

chief nitrogenous waste product. It is formed by the liver which converts harmful nitrogenous products into harmless urea. Carbon dioxide and some water vapour are given out during the exchange of gases. The nitrogenous waste products dissolved in water are carried by the blood to kidneys (Fig. 13.22). The water containing these wastes and the excess of salts are filtered through the fine tubules in the kidney. Excretion helps in the removal of wastes from the body and alter their shapes. Thus they help to bring about movements of the body.

The chief kinds of muscles are the voluntary and involuntary muscles. The voluntary muscles can be controlled by the will of man. They cover the skeleton and are connected to the bones by means of tough, cordlike tendons.

The involuntary muscles are not under the control of the will of man. The muscles in the digestive tract, heart and blood vessels are involuntary muscles.

Digestive System

We have already discussed the digestive system earlier. It involves the conversion of complicated molecules of food into simple, soluble and diffusible molecules. This work goes on in the digestive tracts, (the alimentary canal), with the help of enzymes.

Circulatory System

Circulatory system consists of the heart and three types of blood vessels, arteries, veins and capillaries (Fig. 13.24). The transporting agent is the liquid called blood.

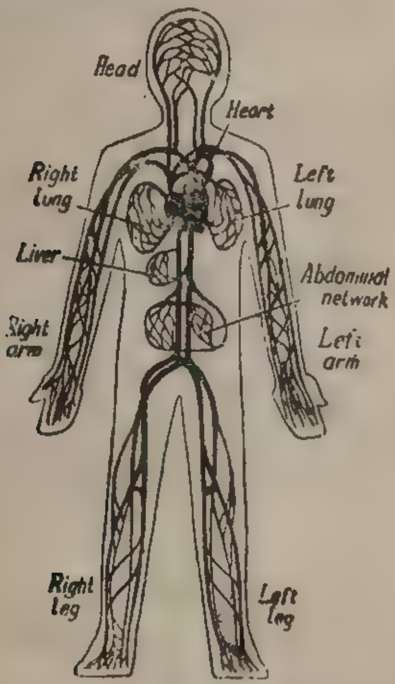


Fig. 13.24. Organs concerned with Blood Circulation

The soluble and diffusible foods in the intestines must be transported to all parts of the body. This work of transport of food is done by the blood which also transports oxygen from lungs to various body parts. The waste material from the body cells are also carried by the blood to special organs so that they may be get rid of. Thus carbon dioxide is carried to the lungs and urea, the chief nitrogenous waste to the kidneys.

Circulatory system also assists to regulate the body temperature. Hormones, secretions of endocrine or ductless glands, are also transported by the blood.

13.9.

Plants have no special system of excretion. The waste product of respiration, carbon dioxide is partly used for photosynthesis. The excess carbon dioxide escapes through the stomata. We have often observed trees shedding leaves and barks. Some waste products get accumulated in barks and leaves. These are got rid of along with them. Some products are transformed into harmless products and stored inside the plant body. In older plant cells, large vacuole contains excretory product which remains inside the plant body for its whole life. Plants secrete a number of products; some of the secretory products of plants are gum, latex, resin, etc.

SUMMARY

1. Organisms differ greatly in form, structure, shape and adaptation, yet there is a thread of unit with regard to the basic life functions.

2. Nutrition is a series of processes including the finding of food, taking of food, digestion, absorption and its utilisation.

3. Nutrition in animals varies from group to group.

4. Food produces energy. It helps the body to grow and to build new tissues.

5. Digestion is a chemical process in which complex food substances are converted into simple substances.

6. First part of the alimentary canal is the mouth, which has teeth.

7. Next part is the oesophagus which is a long tube. No digestion takes place in this part. It leads into stomach.

8. Next the food passes into small intestine where more enzymes act on food.

9. The large intestine is the next part of the alimentary canal. Only water is absorbed here.

10. The undigested food matter is passed out from the rectum through the anus.

11. Respiration is the process by which energy is released from the food in the body cells.

12. Animals breathe in different ways.

13. According to the respiratory surface used for breathing, they are known as body surface breathers, skin breathers, air tube breathers, gill breathers and lung breathers.

14. Plants breathe through stomata present on the lower side of the leaf.

15. Blood is composed of the liquid, plasma, and three kinds of cells, namely the white blood corpuscles, the red blood corpuscles and the platelets.

16. Haemoglobin is a red coloured pigment in the red blood corpuscles, which gives red colour to the blood.

17. Plants have two types of conducting vessels—xylem and phloem.

18. Xylem carries the water and minerals absorbed by the root.

19. Phloem carries food material from the leaves.

20. Xylem and Phloem together are known as vascular bundles.

21. Excretion is the removal of metabolic waste matter from the body.

22. The chief waste products are carbon dioxide, nitrogenous waste, such as urea and water.

23. Plants have no special system of excretion.

24. The waste product of respiration, carbon dioxide, is partly used for photo-synthesis,

25. Trees shed their leaves and bark when some waste products get accumulated in the bark and stem.

QUESTIONS

1. Why is food necessary for our body ?
2. Describe the digestion of food in the various parts of the alimentary canal ?
3. Why do animals respire ?
4. Name three animals that are all body surface breathers.
5. Why do higher animals require a medium such as blood to collect oxygen from the respiratory organs and supply it to different parts of their body ?
6. What is a gill ? Name its parts.
7. How does transport take place in plants ?
8. How does body get rid of waste ?
9. Why do plants shed their leaves ?
10. What is a vascular bundle ?
11. Why do animals have different type of teeth ?
12. What is enzyme ? Of what importance are they ?
13. How does the food material in plants circulate, in different parts ?
14. What happens and why :
    (*a*) When moist bread is kept covered for some time ?
    (*b*) When potted plants are kept in a dark room for a few days ?
    (*c*) When leaf surface is coated with vaseline ?
    (*d*) If there are no green plants in a town ?
15. Given below is a list of organisms in a tabular form.
    Fill up the columns carefully.

No.	*Organism*	*Parasite or Saprophyte*	*Type of food they depend on*
1.	Mosquito	....	....
2.	Mushroom	....	....
3.	Fungi	....	....
4.	Akashbel	....	....
5.	Housefly	....	....

14

PRESERVATION OF SELF—II

14.1. Introduction

Movement is the important characteristic of life. It is found in all the plants and animals. You must have observed that various living organisms move from one place to another. For example a bird flies, a dog runs, an earthworm crawls.

The animals move from one place to another in search of food, shelter and also to save themselves from enemy. Hence they are provided with various locomotory structures.

In plants on the other hand, the displacement from one place to another is not observed because of their characteristic mode of nutrition. The plants show movements in the form of slight curvature while remaining fixed to the ground.

14.2. Movement

Movements can be broadly classified into two types as *locomotion* and *movement of curvature*. Locomotion is the movement in which a living organism moves physically from one place to another. This locomotion is observed mostly in animals, *e.g.*, flying of the butterfly, running of a child, etc. In the latter case movement is in the form of slight bending or curvature of a portion of a body with reference to its body axis. Body does not necessarily has to move from one place to another to show movement. There are various movements going on all the time in our body. Our stomach shows a type of movement when food is taken ; in similarly the heart is beating all the time.

14.3.

Most of the plants show only the movements of curvature. Movements in plants may be due to unequal growth on any side of the organ of the plant. This kind of movement is seen in some creepers and twiners. Movement in plant may be due to contact as seen in case "Touch-me-not", whose leaves get folded when touched. Light and gravity also produce movement in the plants as seen in the following experiments.

Experiment (*a*) : Keep a potted plant near the window of a room which is the only source of light for the room. After a few days it is seen that stem of the plant bends towards light.

Fig. 14.1. The tip of the stem turns towards the source of light.

14.4.

Animals have various organs to help them in locomotion. The lower animals have simple structures for locomotion while higher animals have more complex structures. Lower animals usually move with the help of thread like structure called flagella (*sing.* Flagellum) which produces whip-like movement thus causing locomotion, *e.g.*, Euglena. In paramoecium, movement is caused by numerous hair-like structures called cilia which move synchronously.

Movements in earthworms is caused by the contraction and relaxation of the muscles along with the help of special structures called setae.

14.5.

In higher animals the locomotion is caused with the help of skeleton and muscles. Skeleton is the framework of the body which is made up of bones and cartilage. The bones provide certain stiffness and give the definite and characteristic shape to the body. Skeleton provides surfaces to which muscles are attached and thus helps in locomotion.

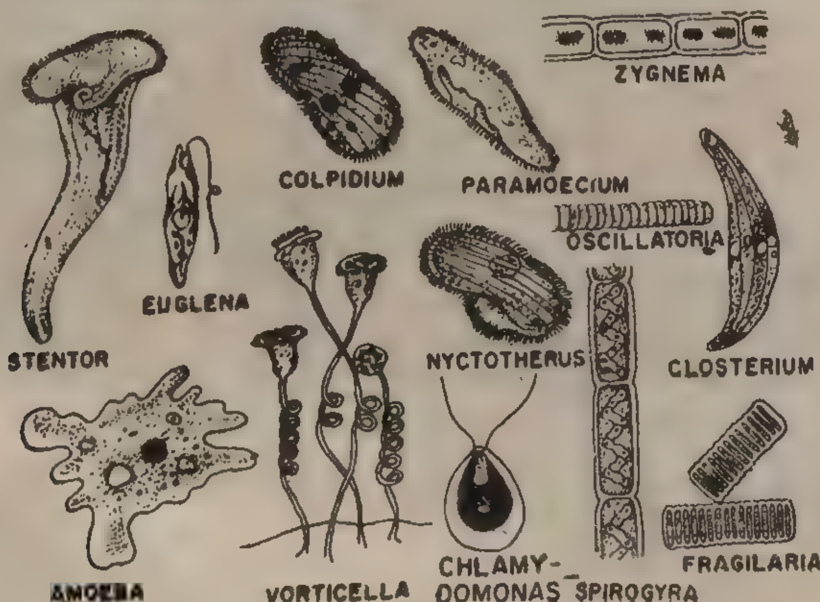


Fig. 14.2.

On examination of human skeleton you will find that it is divided into several parts namely the skull, the vertebral column, the ribs, breast bones, pectoral and pelvic girdles and the limbs. Each of these parts protect a vital internal organ. Human skeleton is made up of 206 bones in total.

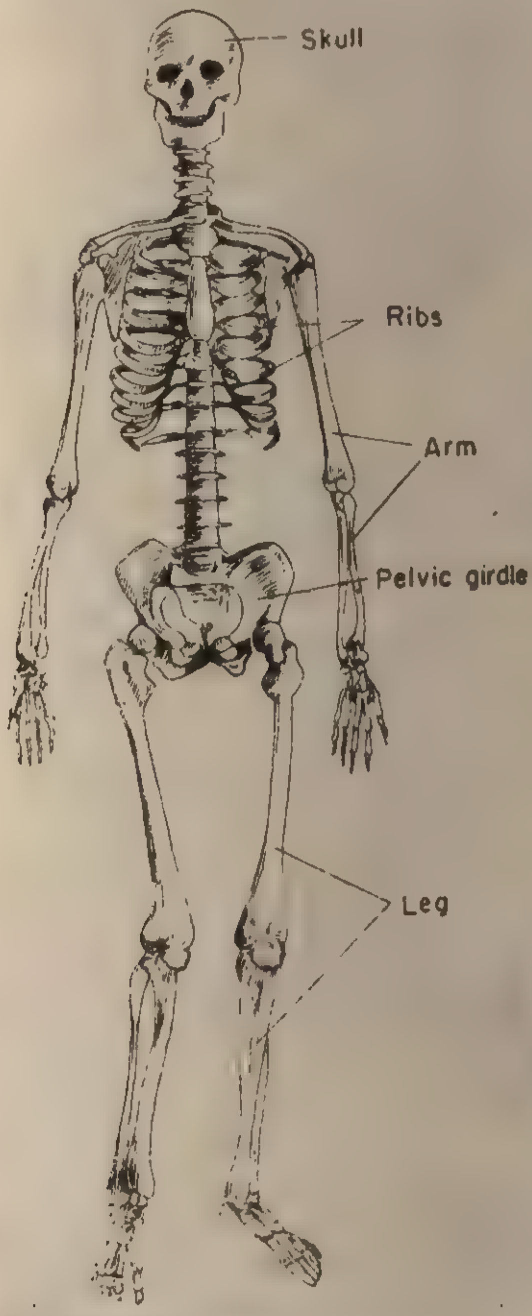


Fig. 14 3. The Human Skeleton

Bones also provide leverage for rapid contraction and relaxation of the muscles. Bones of the skeleton are joined together. A place where two or more bones are articulated is called a joint. The movement occurs at the joints.

The Science of Life

Some bones are fused together and there can be no movement in the joints formed by them. Such a joint is called a fixed joint. Such joints are found in the cranium (Fig. 14.4). Some other joints are joined in such a way that they can move. Such joints are called movable joints.

Movable joints are of several types.

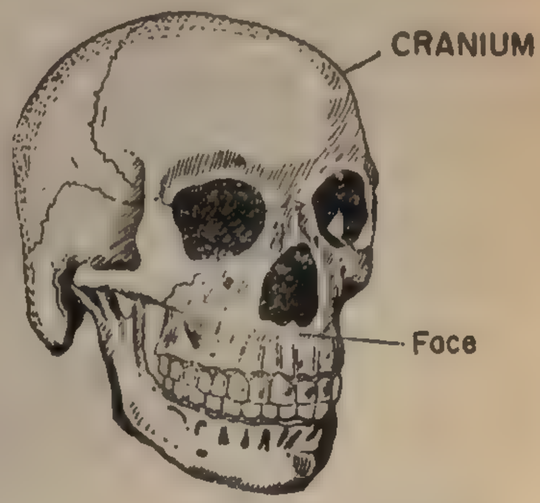


Fig. 14.4. Fixed Joints in the Cranium.

Fig. 14.5. Ball and Socket Joint

(*a*) Ball and Socket joint is formed where the ball-shaped head of one bone fits into the socket of another bone (Fig. 14.5). Can you think of such a joint in your body ? Of course, the shoulder joint, and also the hip joint. What is the advantage of such a joint as regards movement ? Such a joint allows movement in all possible directions, bending and stretching from side to side and also rotatory movements.

Fig. 14.6. Hinge Joint.

(*b*) Hinge joint is formed by the articulation of bones in such a way that movement is possible only in one direction like that in a door (Fig. 14.6). Where do we have such joints in our body ? Hinge joints are found at the elbow, the knee and the fingers.

(*c*) Pivot joint is formed where a ring rotates around a peg or the bones rotate on a ring. Such a joint causes only turning or rotating movement. One example of a pivot joint is the skull rotating on the vertebral column.

14.6.

Muscles are responsible for the movement of various organs of the body. Most of them are attached to the bones at one or both ends. The attachment may be direct or through a tendon which is a band of inelastic connective tissue.

Muscles are usually arranged in antagonistic pairs (flexors and

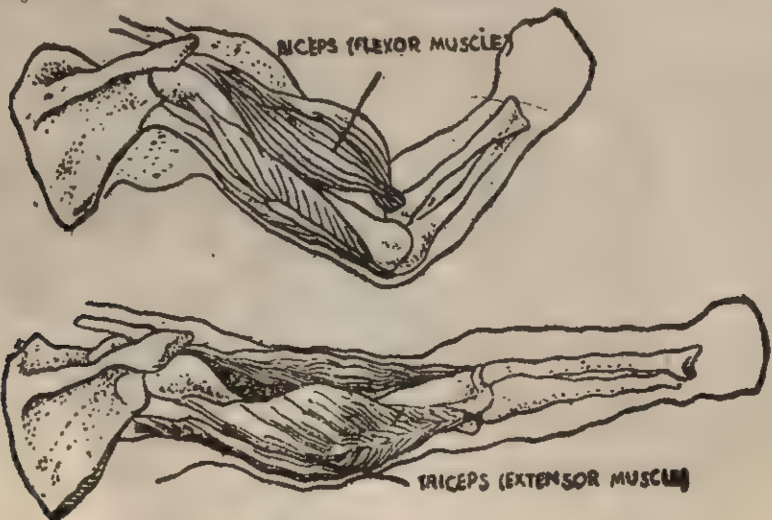


Fig. 14.7. Biceps and Triceps Muscles of the Arm.

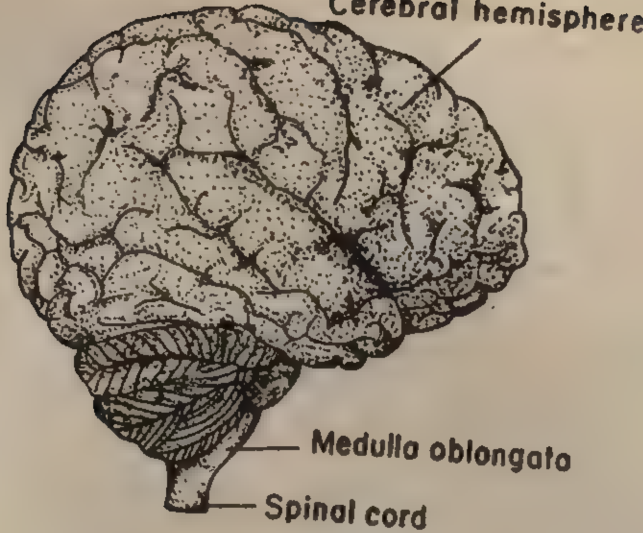


Fig. 14.8. The Human Brain

extensors) which cause opposite movement. ***Flexors*** bend a joint while ***extensors*** straighten it. The muscles which cause movement of bones are called the skeletal muscles or striated muscles.

The muscles of the urinary bladder, intestine, heart and other internal organs are not under the organism's voluntary control and are therefore known as involuntary. On the other hand, the muscles of the legs and arms and all skeletal muscles can be worked at will and are called voluntary.

14.7. Co-ordination

Nervous co-ordination is brought about by nervous system.

The function of the Nervous System is to co-ordinate the various activities within the body. It also brings about proper adjustments in an organism through different responses to external stimuli.

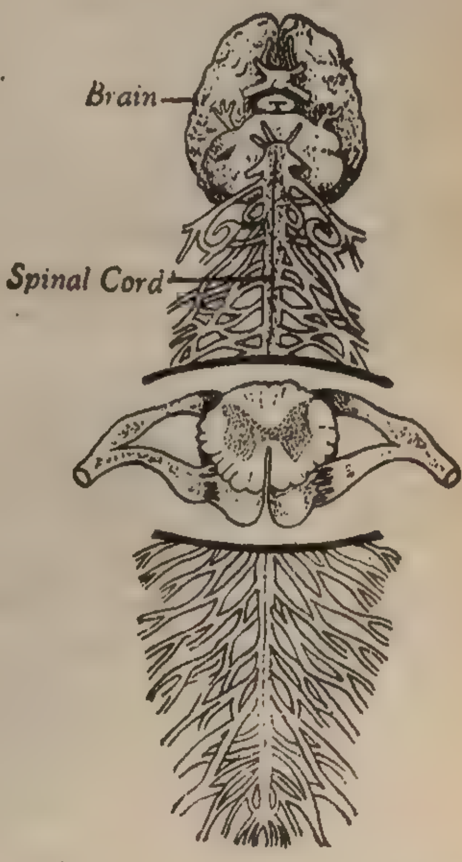


Fig. 14.9. The Nervous System of Man

Nervous system consists of the brain, spinal cord and a large number of nerves (Fig. 14.8 and Fig 14.9). Some of these originate at the receptor organs and end up in brain or spinal cord. Others originate in brain or spinal cord and travel to various parts of the body. All the nerves form a complicated mesh work inside the body. Nerves are the carriers of messages. Brain and spinal cord are the "decision makers" and receptor organs or cells are the places that receive a particular message from the external or internal environment. Eyes, ears, nose, taste buds are important receptor organs that receive stimuli like light, sound, smell, taste respectively. Skin has various receptor cells. It is a very important sensory organ as it is the outer most part of our body and comes in direct contact with the outer world. All receptors are specialised nerve cells. Some of the skin receptors, are Pain receptors, Touch receptors, Pressure receptors, Temperature receptors, etc. If the skin did not have these, it is easy to imagine, how difficult life would become.

In plants various processes of life are controlled by certain growth hormones known as AUXINS. Processes such as flowering, ripening of the fruit, falling of leaves, etc., are controlled by them.

SUMMARY

1. Movement is the basic requirement of life. All the living organisms show movement. Animals move from one place to another for food, shelter and to escape from enemies.

2. Movement is of two types : (*a*) Locomotion *i.e.*, displacement from one place to another. (*b*) Curvature—it is the slight bending of the body, seen mostly in plants.

3. Movements of curvature in plants may be due to unequal growth or due to stimulers such as light, gravity, touch which causes certain organs of plants to bend towards them. Light stimulates stem to bend towards it while roots grow towards gravity.

4. In lower animals the locomotion is produced with the help of cilia and flagella while in worms it is with the help of muscles and setaes.

5. In higher animals the locomotion is brought about by the contraction and relaxation of muscles which are attached to skeleton by means of cord-like, strong tissue called tendon.

6. Skeleton of human beings is made up of 206 bones and it protects the most vital organs of the body such as brain, lungs, and heart, etc. Skeleton give support to the body and also provides surface for the attachment of the bones.

7. Bones also provide leverage for rapid contraction and relaxation of the muscles. The place where two or more bones join is called a joint. The movement occurs at the joints.

8. Joint can be fixed joints which do not provide movements and movable joints which provide movements.

9. Joints are of several types such as : (*a*) Ball and Socket Joint ; (*b*) Hinge Joint ; (*c*) Pivot Joint ; and (*d*) Angular Joint.

10. Muscles are usually arranged in antagonistic pairs (flexors and extensors) which cause opppsite movements.

Those muscles which are controlled by will are called voluntary muscles such as those of legs and arms, while the muscles that cannot be controlled by will are called involuntary muscles as those of urinary bladder, stomach, intestine, etc.

11. Body co-ordination is controlled by nervous systems and endocrine system together. Neither of these can act in isolation.

12. In nervous co-ordination stimulus is received by receptor, which sends the message through a nerve to brain or spinal cord, they take decision. Decision in the form of impulse is sent to the site of action by nerves which results either in the contraction or relaxation of muscle.

13. Chemical co-ordination is brought about by means of chemical substances known as hormones released by ductless glands. These hormones are carried to various parts of the body by blood.

14. Different hormones perform different functions such as promoting growth, metabolism, blood pressure, etc., the pituitary gland produces hormones which control other endocrine glands and hence is called the master gland.

QUESTIONS

1. What is locomotion ? How is it brought about in lower animals ?
2. How many types of movements is seen in plants ?
3. What are the various factors that act as stimuli for plant movement ?
4. Why is skeleton important for higher animals ?
5. Differentiate between voluntary and involuntary muscles by giving examples.
6. What are the various types of joints found in human skeleton ? Explain by giving diagrams.
7. How is the nerve co-ordination brought about in our body ?
8. What is chemical co-ordination ?

9. What is the function of adrenal and thyroid glands ?
10. Why is pituitary gland called the master gland ?
11. Define the following terms :
Locomotion, Co-ordination, Movement of Curvature, Endocrine Glands.
12. What are the functions of :
Cranial cavity, webbed toes in frogs ?
Brain, Spinal cord, Toes of birds ?
13. Fill in the blanks :
(*a*) An earthworm moves by the................and................of the body muscles and by................located on under side of the body.
(*b*) ....provide................for rapid................and................of the muscles.
(*c*) Muscle gets................after work.
(*d*) Organs which receive sensation from outside and communicate to the brain are called................for example................and ....
(*e*) ....is the disease caused by lack of insulin.

15

POPULATION

Population can be defined as the total number of organisms living in an area. In a pond the total population is made up of various types of acquatic plants, fishes of different sizes, snails and also some insects. Similarly in your homes there may be many other organisms living in addition to your family members, such as rats, cockroaches and some insects which also contribute to the population of your homes.

15.1.

Population depends upon various factors. Or we can say that population of various organisms is checked by various factors. Food and space are the two most important factors which greatly influence the population. There is always competition for food and shelter. When the population is on the increase, only those organisms which are stronger are able to survive and leave more progeny for themselves, because only they are able to get food for themselves. It is seen in a jungle where carnivores population increases, they finish up all the herbivores, thus creating food problem for themselves. Some of these carnivores starve to death due to lack of food while other move deep into the jungle for more food, similarly space also proves a very important factor. If the population in an area is continuously increasing then it results in the fight amongst various components of population for shelter and hence checking the population.

Birth rate and death rate also control the population. Amongst various animals, it has been seen that there is a certain balance struck in the birth rate and the death rate which keeps a check on the population. If for certain duration birth rate is on the increase and death rate is reduced then after some time due to scarcity of food and shelter death rate increases remarkably controlling the population. In many animals such as honey bees the population becomes stable after it has been on the increase for sometime. But this is not so in case of human beings. Population of human beings has been on the increase only.

Natural calamities also check population. Certain conditions such as high temperatures during summer, heavy rainfall, very low temperature etc., result in many deaths of various

types of organisms thus controlling the population. Even the human population can not escape these calamities. Many deaths occur due to the floods, cyclone, severe cold etc.

15.2. Population Explosion and its problems :

The discovery of fire made it possible for man to eat food not edible before and to live in the places not previously habitable. The discovery of agricultural methods has enabled him to obtain much more from a given area than could be obtained by primitive gatherers. Irrigation and use of fertilizers have increased the yield many times more. With every increase in efficiency mankind has increased in total number. About 25,000 years ago human population was estimated to be 2 millions. On the other hand at the time of the opening of agricultural revolution the size, number and nature of primitive settlements indicate that a population surge has already taken place. When the hunters and food gatherers became ploughmen and herdsmen, the population increased by about 16 times, during the period 10,000 to 6000 years ago. This was first population explosion. Even though total population at the time of the founding of cities and civilization would have been no more than 50 millions, two thousand years ago this had increased to about 250 million *i.e.*, the population had doubled itself twice during the succeeding 4000 years or once in 2000 years. In all this the basic shift from meat to plants as the major source of food can account for as much as two-fold increase in the human population and remaining two fold increase can be attributed to the increase in efficiency of food production methods. During pre-christian era and present times population increased slowly and reached the mark of 500 million in 17th century *i.e.*, another 2000 years were required for further doubling. The onset of the scientific revolution has also resulted in another great surge in population. Thus in 200 years ending about 1820 the world population doubled again, bringing the total to about 1 billion. The next doubling took only 100 years, and by 1970 only 50 years after last doubling, it doubled again bringing the total to 4 billion. In other words human population as a whole is increasing at an accelerating rate with each doubling taking place about twice as fast as the preceding one, thus resulting in population explosion *i.e.*, of expansion without restraint. The question is when, at what level and by what means will the human population stabilize ?

At the present rate of increase, without any further acceleration in another 700 years would see us with standing space only. Even after 150 years at the end of next century, estimate based on present rate of growth would make the earth look like human ant hill !

The situation appears especially tragic when we consider the fact that the maximal rate of increase of

population exists in those countries which are already the most populous, *e.g.*, India and China. Any material advance in our country is thus offset by simultaneous increase in population. With increase in population food is also becoming scarce resulting in ill nourishment and hunger in highly populated countries.

SUMMARY

1. Population is made of many living organisms living in an area. Types of an organism living in an area is dependent on the conditions prevailing in that area.

2. Different living organisms interact with each other, and this interaction maintains the balance of population.

3. There are many factors that affect the population directly or indirectly. Food and space are most important factor which directly check the population. Other factors are death rate, diseases, natural calamities, *e.g.*, floods, severe temperatures, etc.

4. Population explosion is the expansion without restrain. It has been seen that with increase in efficiency of food products in methods there has been an increase in population as a whole at an accelerating rate with each doubling taking place about twice as fast as previous one.

5. Maximal rate of increase of population exists in those countries which are already most populous, *i.e.*, India and China.

6. Population explosion results in food problem.

QUESTIONS

1. What do you understand by population ?
2. What are the various factors that effect the population ?
3. How does a food and space sets a check on population ?
4. Write an essay on literacy level to population growth in a country.
5. Summarise in brief the measures for population control adopted in India.
6. Define Habitat. List of the different types of Habitat.
7. Why is there competition among the population of different organisms ?
8. How is balance maintained in Population in Nature ?

9. How man is disturbing the population of different organisms today ?

10. How was it confirmed that there exists life on Mars ?

11. Match the following by drawing lines :

A	B
1. Squirrels	Moist and shady places.
2. Mangoose	Sea
3. Mosses	Branches of tall trees.
4. Lotus	On the hills
5. Ferns	Dark corners of kitchen.
6. Seal	Nest within the bushes
7. Cockroach	Desert Lands.
8. Camel	Ponds.

12. How are the following animals related to human beings directly or indirectly :

(*a*) Rats (*b*) Snakes (*c*) Cats (*d*) Dogs

16

POLLUTION

There are human beings, plants and animals in a locality. They all share air, water and soil. So environment in which we live is also the environment for others. This may be disturbed in various ways. The disturbance often cause changes and such changes bring about further disturbances. The addition of any substance in excess of that normally present in the environment also disturbs it. These disturbances are called *Pollution*.

16.1. Air Pollution

The contamination of the air by such substances as toxic dust, vapours and other fumes is called *air pollution*.

The air of most large cities is polluted. It contains tons of material released from smokestacks, industries and motor vehicles. Polluted air is unpleasant to breathe and it contains poisonous substances which are harmful to health. Many physicians believe that polluted air contributes to conditions such as respiratory infections, lung cancer, allergies and several other diseases.

Unburned hydrocarbons, oxides of nitrogen, ozone and sulphur dioxide are some of the chief contaminants present in polluted air. Many of the contaminants result from the burning of coal and fuel oil. Many industries release poisonous gases such as sulphur dioxide and carbon monoxide with the air. Motor vehicles also release unburned hydrocarbons, carbon monoxide and oxides of nitrogen. Oxides of nitrogen such as nitric oxide and nitrogen dioxide are essential to the production of photo-chemical smog that irritates the eyes, nose, throat and lungs.

When waste products from the combination of coal and oil are released into the atmosphere, they form a suspension of finely divided solid particles. These particles are suspended in the gases of the atmosphere. The particles may cause the air to have a gray, hazy appearance and frequently referred to as smoke.

Hydrocarbons and oxides of nitrogen are gases released into the atmosphere in the exhaust from gasoline and diesel engines. When these exhaust gases are acted upon by sunlight, they are chemically changed. One of the products of this chemical change is

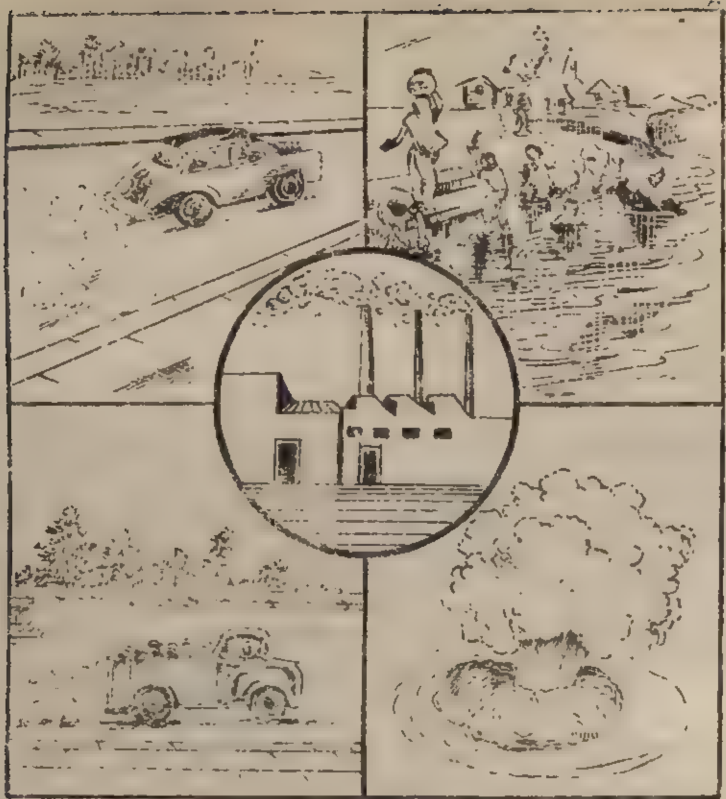


Fig. 16.1. Pollution in Modern Age

ozone. It is of allotrope of oxygen. It causes irritation to the lungs of the nose and throat. Ozone and other gases resulting from a photochemical change are called smog.

16.2. Prevention of Air Pollution

Air pollution can be prevented by different methods.

One method of eleminating air pollution is the filtration and precipitation of the solid particles that are the result of burning coal and oil. Another solution is the reduction of gaseous wastes such as sulphur dioxide and hydrocarbons, by more complete allotrope of oxygen of fuels. Many industries are replacing coal and oil with natural gas. Natural gas oxidizes more completely than coal and oil when it is burned properly. Thus the combination of natural gas produces fewer waste products and less air pollution than the combiration of coal and oil.

Redesigned gasoline engines—that burn fuel more completely are one of the most effective solutions to the air pollution problem. The replacement of internal combustion engines by turbine engines in motor vehicles may offer a long-range solution to air pollution problems. Turbine engines burn fuel more completely, and, therefore, release fewer pollutants into the

atmosphere.

16.3. Water Pollution

Water pollution is a problem in many streams and rivers. In some localities, factory owners dump industrial wastes directly into nearby waters. Some large cities release untreated sewage into the rivers and oceans. These wastes kill the fish and make the water unfit for bathing and other recreational activities.

Sewage treatment plants aid water conservation. In a sewage treatment plant, the sewage is stored in large tanks where it is sedimented constantly as air is passed through it. Harmful compounds are oxidized by the air to form harmless substances. When the process is completed, the sewage may be dumped into river and ocean waters without harmful effects. Also, purified water separated from the sewage can be used for irrigation.

16.4. The World of Noise

Sounds from various sources like radio, microphones, railway engines, aeroplanes, automobiles, construction sites, etc., break the silence of the environment. The noise thus created affects the ear and also causes vibrations in the buildings.

There are a number of natural events in the environment like earthquakes, tidal waves, cyclones, etc., which take heavy toll of human life and properties.

The noise pollution which is increasing day by day affects one's power of hearing. The people who work in mills are subjected to constant exposure to sound and this acts on their power of hearing.

The Scientists have found out that exposure to noise may cause nervous disorder and mental depression.

In order to minimise noise level 'silencers' have been invented for use in automobiles and machines which produce sound. But the best remedy is the individual effort. Practising silence, talking in low pitch, controlling the volume of radio can help.

16.5. Interdependence in the environment

Air, water, soil, plants and animals are important components of our environment and all these are interrelated. Little disturbance to any one component affects the life of all of them. The damage to plant life affects the others. For example, if air is polluted it will affect the herbivorous and this in turn affects the carnivorous. The plants purify air. Absence of plants makes the air rich in carbondioxide. In the absence of plants, the top soil is eroded by air and water. The rain water flows quickly over the rocky layer and this leads to sudden increase in water flow in other parts, where rivers and pools get flooded.

The animals and plants staying in

the environment never do any thing to adversely affect it. It is man who, in fact his attempt to exploit the environment, affects the resources.

SUMMARY

1. Plants and animals also live in the society.

2. They depend on us, we depend on them.

3. The disturbance often cause changes and such changes bring about disturbances.

4. These disturbances are called pollution.

5. The contamination of the air by dust, vapours, etc., is called air pollution.

6. Polluted air is unpleasant to breathe.

7. Filtration and precipitation of solid particles can eliminate air pollution.

8. Water pollution is a problem in many streams and rivers.

9. Some large cities release untreated sewage into the rivers and oceans which causes water pollution.

10. Sounds from various things also break the silence of the environment.

11. Man knowingly or unknowingly spoils these resources causing damage to himself as well as others.

QUESTIONS

1. What is pollution ?
2. What is air pollution ?
3. Define smoke and smog ?
4. What is ozone ? How is it added to the air ?
5. Describe several ways for prevention of air pollution.
6. How does water become polluted ?
7. Why does river water become polluted during rainy season ?
8. Why do some diseases like cholera and typhoid, appear as epidemics ?
9. Noise is disturbing. Is it also harmful for our health ?
10. Why do some ponds and wells dry up during summer ?
11. List the different ways man is responsible for causing pollution.

12. How do the following help in cleaning the atmosphere ?
   (*a*) Fungi and bacteria
   (*b*) Green plants
   (*c*) Silencers in motor bikes and machines.

13. Why is it dangerous to use insecticides in the houses and in fields etc. ?

14. Give reasons—
   (*a*) Why is top soil very essential ?
   (*b*) Why is nicotine harmful ?
   (*c*) Why is it essential to burn the garbage ?